Historic, Archive Document

Do not assume content reflects current
scientific knowledge, policies, or practices.

SUGARBEET RESEARCH

2002 REPORT

FOREWARD

SUGARBEET RESEARCH is an annual compilation of progress reports concerning research by U.S. Department of Agriculture, Agricultural Research Service investigators and other cooperators who are engaged in sugarbeet research. The report was assembled and produced at the expense of the Beet Sugar Development Foundation, and is for the sole use of its members and the cooperators. Much of the data has not been sufficiently confirmed to justify general release and interpretations may be modified with additional experimentation. This report is not intended for publication and should not be used for cited reference nor quoted in publicity or advertising. Reproduction of any portion of the material contained herein will not be permitted without the specific consent of the contributor and the Beet Sugar Development Foundation.

The report presents results of investigations strengthened by contributions received under Cooperative Agreement between the USDA Agricultural Research Service and the Beet Sugar Development Foundation, along with the California Beet Growers Association, the Western Joint Research Committee, and the Sugarbeet and Education Board of Minnesota and North Dakota.

Trade names occur in this report solely to provide specific information and do not signify endorsement by the U.S. Department of Agriculture, the Beet Sugar Development Foundation or any of the cooperating organizations.

CONTENTS

CONTENTS

CONTENTS

SECTION C - FARGO, NORTH DAKOTA (continued)

PROJECT 620

PROJECT 621

PROJECT 622

PROJECT 650

PROJECT 660

SECTION D - EAST LANSING, MICHIGAN

CONTENTS

SECTION D - EAST LANSING, MICHIGAN (continuted)

PROJECT 741

PROJECT 742

PROJECT 743

SECTION E - BELTSVILLE, MARYLAND

PROJECT 810

CONTENTS

SECTION E - BELTSVILLE, MARYLAND (continued)

SUGARBEET RESEARCH

2002 REPORT

Section A

U.S. Agricultural Research Station, Salinas, California

Dr. R.T. Lewellen, Geneticist
Dr. H.Y. Liu, Plant Pathologist
Dr. W.M. Wintermantel, Plant Pathologist
Dr. M.H. Yu, Geneticist
Dr. J.E. Duffus, Collaborator

- - - - - - - - - -

CONTENTS

VARIETY TRIALS (cont.)

ABSTRACTS OF PAPERS PUBLISHED OR APPROVED FOR PUBLICATION, 2002

BIANCARDI, E., R.T. LEWELLEN, M. DeBIAGGI, A.W. ERICHSEN and P. STEVANATO. 2002. The Origin of Rhizomania Resistance in Sugar Beet. Euphytica 127: 383-397.

In the last 35 years, breeding has greatly reduced the damages caused by rhizomania in sugar beet crops. After the first encouraging results using the Alba genotypes, the cultivar Rizor represented a substantial step forward and has given good yield improvement in diseased fields in many parts of the world. The original variety and subsequent improved versions continued to offer good performances for about a decade, after which it was surpassed by other hybrids derived in part from the Rizor itself. Further progress in terms of sugar production became possible in 1986, when the Holly monogerm lines were released in USA and Europe. In spite of the incomplete information about the genealogy of the first resistant materials, many evidences and the molecular analyses on the different genotypes suggest a possible common progenitor and lineage. The resistant cultivars have kept the yield at an adequate level, allowing cultivation to continue in countries where the disease has reached epidemic proportions. The case of rhizomania resistance in sugar beet can therefore be considered as one of the most important achievements in plant breeding.

DE BIAGGI, M., A.W. ERICHSEN, R.T. LEWELLEN and E. BIANCARDI. 2003. Section B, Genetics and Germplasm Enhancement Oral Presentations. J. Sugar Beet Research. In press.

Previously recongised as soil sickness or confused with other sugar beet diseases, the symptoms of rhizomania (in its current meaning) were known in several European countries well before the Second World War. Its rapid spreading was noticed in Italy after 1946, and few years later sporadic symptoms of the disease were observed over 10,000 hectares in areas of intense cultivation. Without knowing the true pathogenic factor, some prophylactic measures were adopted: (1) avoid excess water; (2) avoid spreading of contamination through machinery and tare soil; (3) early harvesting in diseased fields; (4) sowing Italian variety with high sugar content. The last advice was established after a number of field trials that included different commercial varieties. Later became evident that the best entries carried the quantitative resistance named "Alba type." Around 1965, the pathologists involved in such researches could establish that the rhizomania was caused by an atypical fungus-virus symbiosis. With this discovery, the disease was correctly explained, and the word rhizomania became used over many important sugar beet production countries. In the 1970's, both the rapid diffusion of the disease and the worsening of the damages on sugar yield pushed many research institutes and seed companies to find more efficient control measures. After years of searching, two monogenetic traits now known as "Rizor type" and "Holly type" were identified and commercially exploited in Italy (1983) and in U.S.A. (1986), respectively. For both countries, the full and particular background of the discovery of the different rhizomania resistances is given by the breeders involved.

GRUBE, R., E. RYDER, S. KOIKE, J. McCREIGHT, and W. WINTERMANTEL. 2003. Breeding for resistance to new and emerging lettuce diseases in California. Proc. Eucarpia. In press.

Preventing crop loss due to diseases has historically been the primary focus of public lettuce (*Lactuca sativa*) breeding efforts in the United States. Recent years have seen a shift in the industry, with increasing percentages of romaine and mixed lettuces being grown under intensive production systems. Possibly related to this change, several diseases have recently been reported for the first time or have increased in incidence. Two of these, lettuce dieback and crown rot, affect primarily romaine lettuce, whereas a third, Fusarium wilt, threatens all types. Lettuce dieback is caused by soilborne viruses of the family Tombusviridae. This disease may be identical to 'brown blight', which was widespread in the 1940s but vanished when resistant crisphead cultivars were developed. Crown rot of romaine, now known as Phoma basal rot, was first observed in the Salinas Valley of California in 2001. The cause of this disease was recently identified as *Phoma exigua*. Fusarium wilt of lettuce was intially observed in California in 1990, and first caused significant crop losses in both California and Arizona in 2001. Progress and results of breeding for genetic resistance to these diseases will be discussed.

KAFFKA, S.R., R.T. LEWELLEN AND W.M. WINTERMANTEL. 2003. Beet curly top virus, insecticides and plant resistance. Proc. ASSBT 2003. In press.

Beet curly top virus (BCTV), a geminivirus, remains a problem for farmers in the San Joaquin Valley of California. It is spread by the beet leafhopper (*Circulifer tenellus* Baker), which has become naturalized. Recent dependence on non-tolerant sugar beet cultivars has led to increased concern about the potential for a BCTV epidemic, particularly in overwintered crops, which are planted when conditions for infection are greatest. Three trials were carried out in successive years in the western San Joaquin Valley to test the effects of alternative insecticides for control of BCTV on susceptible and tolerant sugar beet cultivars. Two rates of imidicloprid applied as a seed treatment (45g and 90g a.i. per 100,000 seeds) were compared to the current standard treatment of phorate applied to soil at 83.8 g a.i. per 1000 m of row, and an untreated control. In the third trial, clothianidan was also used at the rate of 15 g a.i. per 100,000 seeds. Cultivars ranged in tolerance from the most tolerant line available to the most susceptible cultivar ever observed. In the third trial, different planting dates were also compared. Natural BCTV infection occurred in all three years. Sugar beet root and sugar yields declined linearly with increasing rates of infection. Yields declined because roots were significantly smaller with the non-tolerant cultivar and root populations were reduced by plant loss. Sugar percentage was unaffected by treatments, but differed by cultivar. Imidicloprid and phorate provided similar levels of protection to plants, but were not able to prevent large yield losses among susceptible cultivars when infection occurred early in crop development. Plant resistance provided more effective protection than systemic insecticides.

KAFFKA, S.R., W. M. WINTERMANTEL, and R.T. LEWELLEN. 2002. Comparisons of soil and seed applied systemic insecticides to control *Beet Curly Top Virus* in the San Joaquin Valley. J. Sugar Beet Res. 39(3-4): 59-74

Beet curly top virus (BCTV), a gemini virus, remains a problem for farmers in the San Joaquin Valley of California. It is spread by the beet leaf hopper (*Circulifer tenellus* Baker), which has become naturalized in the state. Recent dependence on non-tolerant sugarbeet cultivars has led to increased concern about the potential for a BCTV epidemic. Two trials were carried out in successive years in the western San Joaquin Valley to test the effects of alternative protective insecticides for control of BCTV on susceptible and tolerant (resistant) sugar beet cultivars. Two rates of imidicloprid applied as a seed treatment (45 g and 90 g a.i. per 100,000 seeds) were compared to the current standard treatment of phorate applied to soil at 83.8 g a. i. per 1000 m of row, and an untreated control. Natural BCTV infection occurred in both years, but the second trial took place during a major beet leaf hopper population increase and infection occurred much earlier in crop development. Sugar beet root and sugar yields declined linearly with increasing rates of infection ($r^2 = 0.856$). Yields declined because roots were significantly smaller with the non-tolerant cultivar. Sugar percentage was unaffected by insecticide treatments, but differed by cultivar. Imidicloprid and phorate provided similar levels of protection to plants, but were not able to prevent large yield losses among susceptible cultivars. Plant resistance provided more protection than systemic insecticides. Changes in land use in the San Joaquin Valley combined with recent adoption of high yielding but non-tolerant cultivars threaten the viability of sugar beet production in affected areas.

LEWELLEN, R.T. 2002. Registration of High Sucrose, Rhizomania Resistant Sugarbeet Germplasm Line CZ25-9. Crop Sci. 42:320-321.

Sugarbeet (*Beta vulgaris* L.) germplasm line CZ25-9 (Reg. no. GP- 219, PI 615520) was developed by the USDA-ARS in cooperation with the Beet Sugar Development Foundation, and the California Beet Growers Association. This line was released in 2001. CZ25-9 is a high sucrose concentration, narrowly based, multigerm (MM), self-fertile (S^f), red hypocotyl (*RR*), diploid line that segregates for genetic male sterility (*aa*). It segregates for the *Rz* allele for resistance to rhizomania, caused by beet necrotic yellow vein virus. In tests at Salinas and Brawley, CA, CZ25-9 had an intermediate to moderately susceptible reaction to sugarbeet *Erwinia*, powdery mildew caused by *Erysiphe polygoni*, curly top virus, and virus yellows. It is intermediate in bolting tendency and resistant to downy mildew, caused by *Peronospora farinosa*. As a line, it has an intermediate sized canopy that is lighter green than most germplasm developed at Salinas and tends to become yellowish late in the season.

CZ25-9 is approximately 50% high sugar Polish germplasm and 50% population 912. Population 912 was developed at Salinas and segregates for self-fertility, genetic male sterility, and resistance to rhizomania. Population 912 is similar to C918 (PI 578079) (USDA, 1993) released in 1993. The Polish component was from nine diploid, multigerm, $S^s S^s$, type-ZZ lines obtained from Dr. H. Szreder, Hodowla Buraka Cukrowego, Poland, in 1988. A composite of the Polish accessions was crossed to genetic male-sterile plants from population 912. Plants from the F_1 population were selected for resistance to rhizomania and increased in bulk. Depending upon the segregation for self-sterility, the F_2 would have been derived by either selfing or sib mating. Thus, recombination was incomplete. Plants from within the F_2 line were selected for resistance to rhizomania and plant type and bulk increased. Again, F_3 individuals

could have resulted from selfing or sibbing, depending upon segregation for self-sterility and genetic male sterility, and could potentially have been S_0's, S_1's, or S_2's. The F_3 was designated Z325 and was one of the components of the population released as CZ25 (PI 599343) (USDA, 1997). Randomly selected pollen fertile plants from Z325 were selfed under paper bags in the greenhouse to produce selfed progeny families. Individual plants would have descended from as few as two plants or through recombination, from as many as 16 initial parental plants. Based upon per se performance for resistance to rhizomania and sucrose concentration, line Z625-9 was selected, increased to produce line Z825-9, and topcrossed to a monogerm tester. Based upon its hybrid performance for sugar yield and sucrose concentration, line Z825-9 was increased to produce line Z025-9. Line Z025-9 is being released as CZ25-9. Distributed seed was produced on the genetic male-sterile segregants within line Z825-9.

CZ25-9 should be evaluated as a potential pollinator to produce high sugar hybrids where resistance to rhizomania is needed but high resistance to other diseases is not. It could be useful also as a high sugar, rhizomania resistant source line for further improvement of sugarbeet. CZ25-9 has a substantially different genetic background than lines traditionally released from the Salinas program (Lewellen, 1992). U.S. plant variety protection will not be sought for CZ25-9. Breeder seed is maintained by the USDA-ARS, and will be provided to sugarbeet researchers in quantities adequate for reproduction, upon request to the author (rlewellen@salinas.ars.usda.gov or rtlewellen@hotmail.com).

LEWELLEN, R.T. 2002. Registration of Monogerm Rhizomania Resistant Sugarbeet Parental Lines C833-5 and C833-5CMS. Crop Sci. 42:321-322.

Sugarbeet (*Beta vulgaris* L.) parental lines C833-5 (Reg. no. PL-38, PI 615522) and C833-5CMS (Reg. no. PL-39, PI 615523) were developed by the USDA-ARS in cooperation with the Beet Sugar Development Foundation and the California Beet Growers Association. These lines were released in 2001. C833-5 is a narrowly based, self-fertile (S^f), red hypocotyl (*RR*), monogerm (*mm*), O-type line that segregates for genetic male sterility (*aa*). It has a high frequency of the *Rz* allele for resistance to rhizomania, caused by beet necrotic yellow vein virus. C833-5 is moderately resistant to bolting and sugarbeet *Erwinia*. It has intermediate resistance to curly top virus, powdery mildew, caused by *Erysiphe polygoni*, and downy mildew, caused by *Peronospora farinosa*. Relative to current commercial hybrids, hybrids with C833-5 perform best under virus yellows infected conditions. C833-5 confers moderately high sucrose concentration and sugar yield to its experimental hybrids. As a line, it has a small, compact, dark green canopy. The reactions of C833-5 to *Cercospora beticola*, *Rhizoctonia solani*, and *Aphanomyces cochliodies* are unknown.

C833-5 was extracted from the initial composite cross used to develop population 833. Population 833 was produced by crossing rhizomania resistant, monogerm, genetic male-sterile plants from population 867 [Population 867 is a rhizomania resistant version of population 767; population 767 was developed from population C310(C6) (PI 590873) x C546 (PI 590649) (Doney, 1995)] with a composite of monogerm, O-type, nonbolting, curly top resistant inbred lines. These lines included C562 (PI 590847), C546 (PI 590649), C718 (PI 590849), C762-17 (PI 560130), C790-15 (PI 564758), C790-68 (PI 590790), C766-62 (PI 560133), C767-46 (PI

560132), and C796-43 (PI 560131) (Doney, 1995). From the initial F_1, rhizomania resistant, monogerm plants were selected and selfed to create selfed progeny lines. Each S_1 family was rogued to genetic male-sterile plants and topcrossed. These topcross hybrids were evaluated in replicated yield and disease evaluation trials. On the basis of these trials, S_1 5833-5 was identified. Plants from 5833-5 were selfed and simultaneously crossed to an annual, male-sterile, O-type tester. Individual S_2 lines were evaluated for resistance to rhizomania and putative homozygous *RzRz* lines identified. The S_2 families that appeared to be O-type and *RzRz* were composited and increased through the segregating genetic male-sterile plants to produce line 0833-5. Line 0833-5 has been released as C833-5. In addition, a near-cytoplasmic-male-sterile equivalent, C833-5CMS, was released. C833-5CMS resulted from the second backcross of C833-5 to the F_1 hybrid C790-15CMS x 5833-5. C833-5CMS has been evaluated as breeding lines 9833-5H0 and 0833-5H0.

C833-5 traces from one fertile (Aa), S_o plant from the composite cross to produce population 833. It is unknown what monogerm, inbred line contributed the male gamete to produce this plant. Because C833-5 is homozygous for red hypocotyl color, all potential sources can probably be eliminated except C790-15 (Lewellen, 1994) or C790-68 (Lewellen and Skoyen, 1987).

Although neither C833-5 nor C833-5CMS is yet used in commercial hybrids, their performance in experimental hybrids and combined disease resistance make them potential candidates for use as a parental line. C833-5 may be useful as a source for continued line improvement. U.S. plant variety protection will not be requested for C833-5 or C833-5CMS.

Breeder seed is maintained by the USDA-ARS and will be provided to sugarbeet researchers in quantities adequate for reproduction, upon request to the author (rlewellen@salinas.ars.usda.gov or rtlewellen@hotmail.com).

LEWELLEN, R.T. 2002. Registration of Sugarbeet Germplasm CR09-1 with Dual Resistance to *Cercospora* and Rhizomania. Crop Sci. 42: 672-673.

Sugarbeet (*Beta vulgaris* L.) germplasm line CR09-1 (Reg. no. GP- 220, PI 615521) was developed by the USDA-ARS in cooperation with the Beet Sugar Development Foundation and California Beet Growers Association. This line was released in 2001. CR09-1 is a narrowly based, multigerm (*MM*), self-fertile (*S^f*), red hypocotyl (*RR*), diploid line that segregates for genetic male sterility. It segregates for the *Rz* allele for resistance to rhizomania, caused by beet necrotic yellow vein virus. In addition, the resistance to rhizomania found in line C79-6 (PI 593665) may occur (Lewellen, 1997). CR09-1 has fair resistance to cercospora leaf spot, caused by *Cercospora beticola*, based upon nursery tests at Salinas, CA, Fort Collins, CO, and Shakopee, MN. CR09-1 has moderate resistance to sugarbeet *Erwinia* and downy mildew, caused by *Peronospora farinosa*. It has an intermediate reaction to bolting, curly top virus, powdery mildew, caused by *Erysiphe polygoni*, and virus yellows complex caused by beet yellows and beet western yellows viruses. In bolted, seed production phase, CR09-1 has a tendency for plant loss due to a crown rot of unknown cause. This crown rot has not been observed in the vegetative rosette stage or in its experimental hybrids. As a line, CR09-1 has a

small canopy with erect leaves and only fair vigor and seed yield potential. Its experimental hybrids have large, upright canopies.

CR09-1 was isolated from a population similar to CR09 (PI 593692) (USDA, 1996) released in 1996. An Italian accession with resistance to cercospora leaf spot and rhizomania called R05 was obtained from E. Biancardi at Rovigo, Italy, in 1987. This line was crossed to Salinas population 747 that has moderate to high resistance to curly top, Erwinia, virus yellows, and bolting. After one cycle of recombination, stecklings from this F_2 were crossed to population 918 (PI 578079) (USDA, 1993). Population 918 is similar to 747 but has resistance to rhizomania. After one cycle of full-sib family selection for combined resistance to rhizomania and cercospora leaf spot, the synthetic R409 was produced. Individual plants from R409 were selfed to produce S_1 progeny. These S_1 progeny families were evaluated for dual resistance to rhizomania and cercospora leaf spot at Salinas. An increase of the family with the best combination of disease resistance and agronomic traits was designated R709-1. One additional cycle of mass selection for resistance to rhizomania was made within this line to produce line CR909-1. CR901-1 was increased through segregating genetic-male-sterile plants to produce line CR009-1 and released as CR09-1.

At the same time that the bulk increases of this line were being made, it was crossed to a monogerm, cytoplasmic-male-sterile tester. Productions of this testcross hybrid were evaluated in disease and yield trials at Salinas and Brawley, CA. These trials showed that CR09-1 has good combining ability for sugar yield with intermediate sucrose concentration.

CR09-1 may be useful as a germplasm source for further improvements in resistance to cercospora leaf spot combined with other diseases. It needs to be evaluated as a potential pollinator of commercial hybrids where resistance to both rhizomania and *Cercospora* are needed. Because the source of resistance to *Cercospora* is from a recent Italian accession, it may be of interest to determine if this resistance is the same as in the traditional USDA *Cercospora* resistant base or if CR09-1 may contribute new and complementary genes to *Cercospora* resistant breeding programs. U.S. plant variety protection will not be sought for CR09-1.

Breeder seed is maintained by the USDA-ARS and will be provided to sugarbeet researchers in quantities adequate for reproduction, upon request to the author (rlewellen@salinas.ars.usda.gov or rtlewellen@hotmail.com).

LEWELLEN, R.T., H.-Y. LIU, W.M. WINTERMANTEL, and J.L. SEARS. 2003. Inheritance of Beet Necrotic Yellow Vein Virus (BNYVV) Systemic Infection in Crosses Between Sugarbeet and *Beta Macrocarpa*. J. Sugar Beet Research. In press.

Beet necrotic yellow vein virus (BNYVV), the cause of rhizomania, rarely infects sugarbeet (*Beta vulgaris* L.) systemically. Conversely, from mechanical inoculation BNYVV almost always systemically infects *B. vulgaris* subsp. *macrocarpa* (*B. mac*) line that grows as a weedy annual in the Imperial Valley of California. This *B. mac* has been used for many years in the virology programs at Salinas as an indicator host for virus assays. *B. mac* shows other reactions to viruses that are of interest. When infected young, *Beet yellows*, *Beet mosaic*, and *Beet curly top viruses* kill *B. mac*. Other "nonbeet" viruses, e.g., *Lettuce mosaic virus*, readily produce

systemic infection in *B. mac* but not in sugarbeet. It was of interest to determine the genetic basis of these different host-plant reactions. *B. mac* is a very easy bolting annual and highly self-fertile and successful crosses were achieved only when sugarbeet was used as the female. Color patterns and annualism were used as markers to positively identify F_1 hybrids. The very limited number of F_1 plants tested had the virus reaction of sugarbeet or were intermediate. The F_2 suggested that BNYVV systemic infection was conditioned by a homozygous recessive factor but the lack of fit may have been caused by escapes and lethal and sublethal mutant plants and to incomplete expressivity. F_3 population and F_3 line patterns also suggested recessive inheritance, but again ratios appeared disturbed. Most F_3 plants produced from F_2 plants with systemic infection to BNYVV were susceptible to systemic infection and there was no evidence for seed transmission. Evaluation of segregating populations is continuing with the intent to produce a biennial line with the virus reactions of *B. mac* and to determine if different genes for host reaction are involved for each virus or if one recessive factor is predisposing *B. mac* to be widely susceptible to systemic infection by numerous viruses.

LIU, H. Y. 2002. The epidemiology study of whitefly-transmitted criniviruses in southwestern United States. In Proc. VIII International Plant Virus Epidemiology Symposium, pg. 100. Aschersleben, Germany, May 12-17, 2002.

In 1981, lettuce, cucurbits, and sugarbeet crops in the southwestern United States were ubiquitously infected with *Lettuce infectious yellows virus* (LIYV), resulting in losses exceeding $20 million in one growing season. LIYV is a *Crinivirus*, which is classified as a new genus of *Closteroviridae* family. The cucurbits appear to play an important role in the epidemiology of LIYV. The cucurbits are a breeding host of the whitefly and also serve as a source of LIYV for newly emerging crops in early September. In 1990-1991 the incidence of LIYV in the desert areas were reduced from 70% to 1% in spite of the record high population of its insect vector, the sweetpotato whitefly (*Bemisia tabaci*). With a hypothesis of the vector population shifting to a new biotype with no or low efficiency of virus transmission, we surveyed the desert areas for whitefly and found a new biotype: "B". This biotype "B" is different from the original biotype "A" in host preference, larval development, transmission efficiency of LIYV, and the induction of silverleaf symptom on squash, but is indistinguishable morphologically from biotype "A". We developed an isozyme pattern technique to differentiate biotype "B" from biotype "A". Since 1991, a mixture of viruses including LIYV and a newly descried clostero-like virus termed *Lettuce chlorosis virus* (LCV) have been isolated from sugarbeet and lettuce plants in the desert regions. B-biotype whitefly can transmit LCV efficiently. However, because cucurbits are not LCV hosts, the only known virus source in the field is from the weed hosts. Therefore, so far LCV has not caused severe losses to crops.

LIU, H. Y. 2002. Whitefly-transmitted criniviruses in lettuce and tomato. In Proc. XI National Congress of the Spanish Phytopathological Society, pg. 308. October 14-18, Almeria, Spain, 2002.

Whitefly-transmitted criniviruses are an expanding group of plant viruses. *Crinivirus* is a new genus belongs to *Closteroviridae* family. The criniviruses have been characterized by a number of features

including particle morphology, cytopathology, mode of transmission, and bipartite single stranded RNA genome.

In 1981, lettuce, cucurbits, and sugar beet crops in the southwestern United States were ubiquitously infected with *Lettuce infectious yellows virus* (LIYV), resulting in losses exceeding $20 million in one growing season. The cucurbits appear to play an important role in the epidemiology of LIYV. The cucurbits are a breeding host of the whitefly and also serve as a source of LIYV for newly emerging crops in early September. In 1990-1991 the incidence of LIYV in the desert areas were reduced from 70% to 1% in spite of the record high population of its insect vector, the sweetpotato whitefly (*Bemisia tabaci*). With a hypothesis of the vector population shifting to a new biotype with no or low efficiency of virus transmission, we surveyed the desert areas for whitefly and found a new biotype: "B". This biotype "B" is different from the original biotype "A" in host preference, larval development, transmission efficiency of LIYV, and the induction of silverleaf symptom on squash, but is indistinguishable morphologically from biotype "A". We developed an isozyme pattern technique to differentiate biotype "B" from biotype "A". Since 1991, a mixture of viruses including LIYV and a newly descried clostero-like virus termed *Lettuce chlorosis virus* (LCV) have been isolated from sugar beet and lettuce plants in the desert regions. B-biotype whitefly can transmit LCV efficiently. However, because cucurbits are not LCV hosts, the only known virus source in the field is from the weed hosts. Therefore, so far LCV has not caused severe losses to crops.

Since 1993, we have discovered at least two distinct tomato-infecting criniviruses, *Tomato infectious chlorosis virus* (TICV) and *Tomato chlorosis virus* (ToCV), both in field and greenhouse grown tomatoes. These viruses have wide host ranges and include ornamentals, weeds, and agronomic crops. TICV has been identified in limited locations within the U.S., as well as in Europe and Taiwan, while the distribution of ToCV appeared to be considerably broader. ToCV has been identified in North America, Europe, Taiwan, South America, and most recently the Caribbean. Although TICV is only transmitted by the greenhouse whitefly (*Trialeuordes vaporariorum*), four whitefly vectors transmit ToCV, including *T. vaporariorum*, *B. tabaci* A and B biotypes, and the banded wing whitefly (*T. abutilone*). Both TICV and ToCV are considered to be semi-persistent in their vectors. TICV persists in the whitefly for four days, whereas ToCV persists one day in the vector. Movement of these viruses in breeding material and increases in both international trade and greenhouse vegetable culture contributes to the expansion of the natural range of these viruses.

LIU, H. Y., J.L. SEARS, and R.T. LEWELLEN. 2002. Partial characterization of an unnamed soil-borne sugar beet virus in the United States. in Proc. 5th. Symp. International Working Group on Plant Viruses with Fungal Vectors, Zurich, Switzerland, July 22-25, 2002. In press.

In rhizomania infested fields, sugar beet leaves with oak-leaf pattern symptoms different from rhizomania were found in California. A virus with rigid rod-shaped particles was isolated. For purposes of discussion this unknown virus was designated Beet oat-leaf virus (BOLV). BOLV is serologically distinct from *Beet necrotic yellow vein virus* (BNYVV), *Beet soil-borne mosaic virus* (BSBMV), and *Beet soil-borne virus* (BSBV). The host range of BOLV is similar to BNYVV and BSBMV mostly infecting *Chenopodiaceae* plants. BOLV produces chlorotic local lesions with a necrotic ring after mechanical inoculations. Particles were about 20 nm wide and

ranged from 80 to 640 nm with three modal lengths: 180-200 nm, 260-280 nm, and 300-320 nm. *Polymyxa betae* transmission of BOLV was demonstrated through a bioassay by using BOLV-infected cystosori and sugar beet as bait. BOLV has been purified from *Spinacia oleracea*. The molecular mass of the capsid protein was estimated to be 46.0 kDa. A polyclonal antibody from rabbits has been produced and can be used in ELISA, western blot, and immunogold labeling tests. BOLV appears to be wide spread in U.S. It has been found also in Colorado, Michigan, Minnesota, Nebraska, and Wyoming. BOLV was found in sugar beet alone or co-infected with BNYVV and/or BSBMV. The economic significance of BOLV and its interaction with other furoviruses are not known.

LIU, H.Y., J.L. SEARS, and R.T. LEWELLEN. 2003. <u>A New Beny-Like Sugarbeet Virus Emerging in the United States</u>. J. Sugar Beet Research. In press.

A virus with rigid rod-shaped particles was isolated in addition to *Beet necrotic yellow vein virus* (BNYVV) from rhizomania infested fields in California. The infected sugarbeet leaves showed oak-leaf pattern symptoms different from rhizomania. For purposes of discussion this unnamed virus will be tentatively called Beet oat-leaf virus (BOLV). BOLV is serologically distinct from BNYVV, *Beet soil-born mosaic virus* (BSBMV), and *Beet soil-borne virus* (BSBV)/*Beet virus Q* (BVQ). The host range of BOLV is similar to BNYVV and BSBMV mostly infecting *Chenopodiaceae* plants. BOLV produces chlorotic local lesions with a necrotic ring after mechanical inoculations. Particles were 18 to 20 nm wide and ranged from 80 to 640 nm long with three modal lengths: 180-200 nm, 260-280 nm, and 300-320 nm. *Polymyxa betae* transmission of BOLV was demonstrated through a bioassay by using BOLV-infected cystosori and sugarbeet as bait. BOLV has been purified from *Chenopodium quinoa*. The molecular mass of the capsid protein was estimated to be 43.0 kDa. A polyclonal antibody from rabbits has been produced and can be used in ELISA and immunogold labeling tests. BOLV appears to be wide spread in U.S. It has been found also in Colorado, Michigan, Minnesota, Nebraska, and Wyoming. BOLV was found in sugarbeet alone or co-infected with BNYVV and/or BSBMV. The economic significance of BOLV and its interaction with other benyviruses are not known.

LIU, H. Y., J.L. SEARS, and R.H. MORRISON. 2003. <u>Isolation and characterization of a carom-like virus from *Calibrachoa* plant</u>. Plant Disease. Plant Dis. 87:167-171.

Spherical virus particles c. 29 to 31 nm in diameter were isolated from *Calibrachoa* plants showing leaf mottling and chlorotic blotch symptoms. The virus was mechanically transmitted to *Chenopodium amaranticolor*, *C. capitatum*, *C. quinoa*, *Nicotiana benthamiana*, and *N. clevelandii* plants, but was not transmitted by green peach aphid (*Myzus persicae*), sweetpotato whitefly (*Bemisia tabaci*), silverleaf whitefly (*B. argentifolii*), greenhouse whitefly (*Trialeurodes vaporarium*), or banded-wing whitefly (*T. abutilonea*). Virions contained a single species of single-stranded RNA of approximately 4.0 kb and a single capsid protein of approximately 41 kDa. The double-stranded RNA pattern consistently revealed one major band of about 4.0 kbp, and three minor dsRNA of c. 3.1, 1.6, and 1.3 kbp. The virus-infected plants reacted with a homologous polyclonal antiserum in indirect enzyme-linked immunosorbent assay. The genome contained a sequence of a highly conserved motif of the RNA-dependent RNA-polymerase associated with the

genus *Carmovirus*, and shared 94% identity with *Carnation mottle carmovirus* (CarMV). However, the *Calibrachoa* virus and CarMV serologically and host range were distinct. Based on the host ranges, particle morphology, dsRNA profile, properties of particles in sap, and features of the genome and protein, we concluded that the recently observed *Calibrachoa* disease is caused by a previously undescribed carmovirus on *Calibrachoa* plants. We propose to name this virus Calibrachoa mottle virus (CbMV).

OBERMEIER C., J.L. SEARS, H.Y. LIU, K.O. SCHULETER, E. RYDER, J.E. DUFFUS, S.T. KOIKE, and G.C. WISLER. 2002. Disease of lettuce and tolmato caused by tombusviruses in the western United States. In Proc. 10th Conference of ISHS Working Group on Vegetable Viruses pg. 10. August 4-9, Bonn, Germany, 2002.

A new soil-borne virus related to *Tomato bushy stunt virus* (TBSV) and associated with dieback has been found in romaine and leaf lettuce in California and Arizona. Heavy rains and flooded land in the past several years may have caused the emergence of this soil- and water-borne virus. At the same time, a tombusvirus has also been found associated with a necrosis inducing disease of greenhouse tomatoes in Colorado, New Mexico, and Texas. An antiserum was produced against a tombusvirus isolate obtained from diseased lettuce. Agar gel double diffusion and Western blot analyses revealed that the tombusviruses repeatedly isolated from diseased lettuce and tomato plants are serologically distinct from previously described tombusvirus species and strains. Sequences of cDNA clones generated from the 3'-end of viral genomic RNA from diseased lettuce and tomato plants were identical. These sequences were divergent (12-17%) from those of previously described strains of TBSV. Based on genomic and serological properties we propose to classify this virus as a new tombusvirus species termed *Lettuce necrotic stunt virus* (LNSV). In some cases other tombusviruses that were closely related to the previously described TBSV-Cherry strain and to *Cucumber necrosis virus* (CNV) were also recovered from asymptomatic and symptomatic lettuce and tomato plants. However, typical symptoms of die-back and necrosis on lettuce and tomato were induced only after soil inoculation of lettuce and tomato plants with LNSV-containing plant sap. LNSV was reisolated from symptomatic leaves indicating that the virus is the causal agent. In contrast, the TBSV-Cherry and CNV isolates recovered from asymptomatic lettuce and tomato plants did not induce typical dieback symptoms on lettuce or fruit necrosis in tomato after soil inoculation of lettuce and tomato plants with virus-containing plant sap. However, the role of TBSV-Cherry and CNV in the etiology of lettuce dieback disease and necrosis-inducing disease of tomato in the Western United States still needs further evaluation. Attempts to control dieback disease of lettuce in field trials by fumigation of infested soil using methyl bromide or a combination of methyl bromide and chloropicrin were not successful suggesting that no biological soil-borne vector was involved in natural virus transmission. Natural resistance to LNSV was found in field trials in two consecutive years in 5 out of 8 crisphead varieties and in 4 out of 12 leaf lettuce varieties, but in 0 out of 20 romaine varieties tested. Sources of natural resistance were identified in four romaine lettuce lines that are currently used to produce resistant romaine lettuce varieties. Dieback disease symptoms and resistance characteristics of crisphead varieties tested resembled those of crisphead varieties developed in the 1920s to control brown blight disease of lettuce. These results suggest a common origin of brown blight disease of the 1920s and dieback disease of lettuce of the 1980s and 1990s. The reoccurrence of this dieback disease of lettuce caused by

Lettuce necrotic stunt virus may have been facilitated by the decrease in acreage grown in resistant crisphead varieties and the increase in acreage grown in susceptible leaf and romaine lettuce varieties in California and Arizona within the last 20 years.

WEILAND, J.J. and M.H. YU. 2003. <u>A Cleaved Amplified Polymorphic Sequence (CAPS) Marker Associated With Root-Rot Nematode Resistance in Sugarbeet (*Beta vulgaris* L.)</u>. Crop Science 43: In press.

Resistance to root-knot nematode (*Meloidogyne* spp.) previously was introgressed into sugarbeet (*Beta vulgaris* L.) from wild beet [*B. vulgaris* ssp. *maritima* (L.) Arcang] and was demonstrated to be dominant and simply inherited. Since resistance conferred by this gene was effective against six different species of *Meloidogyne* spp. tested, the locus was designated **R6m-1**. An inter-pollinated progeny population of resistant heterozygotes segregating for ***R6m-1***, was exposed to nematodes in a greenhouse and rated for root knot disease symptoms. Resistance vs. susceptibility segregated at approximately a 4:1 ratio and 120 resistant roots and 48 susceptible roots were chosen for the generation of a molecular **marker** linked to the resistance trait. Bulked DNA samples prepared from shoots sprouting from the selected plants were subjected to RAPD analysis, yielding a marker of 600 bp that was highly associated with resistance. Sequence analysis of the 600 bp product led to the design of DNA primers for specific amplification of a 580 bp product, the generation by PCR of which occurred in plants both susceptible and resistance to nematode. Comparison between the sequences generated from resistant plants and susceptible plants revealed numerous nucleotide substitutions. One base substitution associated in repulsion with resistance conditioned the existence of a recognition site for cleavage by the restriction endonuclease *Mse* I. Amplification and cleavage of the product with *Mse* I yielded a cleaved amplified polymorphic sequence (CAPS) marker designated Nem06 that co-segregated with resistance to the root knot nematode. Computer-assisted translation and comparison with sequences in public databases indicates that the marker DNA sequence encodes a protein with high sequence similarity to a plant transcription factor.

WINTERMANTEL, W.M. and A.G. ANCHIETA. 2003. <u>Tombusvirus infection of lettuce is influenced by soil salinity</u>. Proc. International Working Group on Plant Viruses with Fungal Vectors, 2002. In press.

A severe soil-borne disease of lettuce has emerged to cause severe losses for lettuce production in the western United States. The disease is caused by a group of tombusviruses, including both *Tomato bushy stunt virus* and the newly described *Lettuce necrotic stunt virus*. Fields with severe infections are usually associated with areas near rivers and areas where flooding has recently occurred. Interestingly, disease severity in infested fields varies considerably from year to year. In order to identify factors contributing to variability in infection, soil analyses were conducted on adjacent fields with similar soil type, but differing for tombusvirus infection. These studies identified soil salinity as the predominant factor differing between diseased and disease-free fields. Subsequent greenhouse studies examined the effect of electrical conductivity levels in the soil on virus infection. Results indicated that elevated electrical conductivity (5.5 dS/cm^3) led to elevated levels of LNSV infection when

compared with a lower electrical conductivity (3.2 dS/cm^3), which exhibited very low disease incidence.

WINTERMANTEL, W.M., T. CROOK, and R. FOGG. 2003. First report of rhizomania disease of sugar beet in the Great Lakes production region. Plant Disease 87 (2): 201.

Rhizomania, caused by *Beet necrotic yellow vein virus* (BNYVV) and vectored by the soil-borne fungus *Polymyxa betae* Keskin, is one of the most economically damaging diseases affecting sugar beet (*Beta vulgaris* L.). The virus likely originated in Europe, and was first identified in the United States in 1983 in California (1). It has since spread among American sugar beet production regions in spite of vigorous sanitation efforts, quarantine, and disease monitoring (3). In the fall of 2002, mature sugarbeet plants exhibiting typical rhizomania root symptoms (2) were found in several fields scattered throughout central and eastern Michigan. Two to five sugarbeet root samples were collected from each field and sent to the USDA-ARS in Salinas, CA for analysis. Roots were washed and tested by DAS-ELISA for the presence of BNYVV using standard procedures and antiserum specific for BNYVV (3). Sugar beet roots were tested individually, and samples were considered positive when absorbance values were at least three times those of greenhouse-grown healthy sugar beet controls. Samples were tested from 16 fields, with 10 confirmed positive for BNYVV. Fields were considered positive if one beet tested positive for BNYVV, but in most cases all beets tested from a field were either uniformly positive or uniformly negative. Fields testing positive for BNYVV were widely dispersed within a 100 square mile area including portions of Gratiot, Saginaw, Tuscola and Sanilac Counties in the central and eastern portions of the lower peninsula of Michigan. The confirmation of rhizomania in sugar beet from the Great Lakes region marks the last major American sugarbeet production region to be diagnosed with rhizomania disease, nearly 20 years after its discovery in California (1). There were approximately 185,000 acres of sugar beet grown in the Great Lakes region in 2002, located in Michigan, Ohio, and southern Ontario, Canada. The wide geographic distribution of infested fields suggests the entire region should monitor for symptoms, maintain a minimum 3 to 4 year rotation to nonhost crops, and consider planting rhizomania resistant sugar beet varieties to BNYVV-infested fields.

WINTERMANTEL, W.M., N.F. MOSQUEDA, A.A. CORTEZ, and A.G. ANCHIETA. 2003. Beet curly top virus revisited: Factors contributing to recent severe outbreaks in California. Proc. ASSBT 2003. In press.

Beet curly top virus (BCTV), transmitted by the beet leafhopper (*Circulifer tenellus)* has caused significant problems to irrigated agriculture in the western United States since the late 1800s. Although managed annually through an intensive leafhopper eradication program, BCTV re-emerged in 2001 as a serious threat to agriculture in California's San Joaquin Valley. BCTV infects a broad range of crop hosts including sugarbeet, pepper, tomato, bean, spinach, and cucurbits, as well as numerous weeds. Although many strains of BCTV have been identified over the years, molecular characterization of BCTV in sugarbeet has demonstrated that the virus primarily exists as genetic variants of three strains, CFH, Worland, and California/Logan. Studies conducted in the early 1990s determined that most sugarbeets were infected with either

CFH or Worland strains, but little information exists on strain distribution among weed hosts. Data collected over the past 2 years in California and other states has focused on molecular characterization of BCTV isolated from weed hosts present in the over wintering grounds of the beet leafhopper, as well as sugarbeet and selected other crops. PCR using BCTV universal primers, as well as strain specific primers have been used to amplify viral DNA from infected crop and weed hosts from both fields and overwintering grounds of the beet leafhopper. Strain identification coupled with sequence analysis provides insight into variability in virus population structure over broad areas, as well as over time.

WISLER, G.C., R. T. LEWELLEN, J. L. SEARS, H.-Y. LIU, J. W. WASSON, and W. M. WINTERMANTEL. 2003. Effects of two soil-borne viruses of sugarbeet and their fungal vector, *Polymyxa betae*, on virus accumulation and plant growth in sugarbeet. Proc. ASSBT 2003. In press./ Proc. Internal. Working Group Plant Viruses Fungal Vectors. In press.

Soils naturally infested with cultures of aviruliferous *Polymyxa betae* and viruliferous *P. betae* carrying the two sugar beet benyviruses *Beet necrotic yellow vein virus* (BNYVV) and *Beet soil-borne mosaic virus* (BSBMV), alone and in combination, were compared to non-infested soil with regard to their effects on virus content, fresh plant weight, and seedling emergence. Two sugar beet varieties were used: a diploid (*Rzrz*) that carries resistance to rhizomania caused by BNYVV, and a triploid rhizomania-susceptible variety (*rzrzrz*). These studies clearly demonstrated that the Rz resistance gene does not confer resistance to BSBMV. Additionally, *P. betae* alone had a significant negative effect on growth of sugarbeet, and soils infested with *P. betae* containing one or both viruses, tended to have reduced seedling emergence and reduced fresh weight, even when protective fungicides were used. BSBMV titers were significantly higher in single infections than in mixed infections with BNYVV in both rhizomania resistant and susceptible varieties. In contrast, BNYVV titers were very high in single and in mixed infections in the Rhizomania-susceptible variety, but low in the resistant variety. Therefore, in the absence of BNYVV, BSBMV concentrations are high in infected roots, regardless of the resistance genotype. In the presence of BNYVV, however, BSBMV concentrations are low in both resistant and susceptible varieties, with absorbance readings similar to those of plants grown in non-infested soils. It appears that even at low levels, BNYVV either out competes or suppresses BSBMV, and suggests that both viruses target similar cellular processes in the sugarbeet plant.

WISLER, G.C., R.T. LEWELLEN, J.L. SEARS, J.W. WASSON, H.-Y. LIU, and W.M. WINTERMANTEL. 2003. Interactions Between *Beet Necrotic Yellow Vein Virus* and *Beet Soil-Borne Mosaic Virus* in Sugar Beet. Plant Disease 87. In press.

Soils naturally infested with cultures of aviruliferous *Polymyxa betae* and viruliferous *P. betae* carrying two sugar beet benyviruses, *Beet necrotic yellow vein virus* (BNYVV) and *Beet soil-borne mosaic virus* (BSBMV), alone and in combination, were compared to non-infested soil for their effects on seedling emergence, plant fresh weight, and virus content as measured by ELISA. Two sugar beet varieties were used: a diploid (*Rzrz*) carrying resistance to the disease, rhizomania, caused by BNYBB, and a triploid rhizomania-susceptible variety (*rzrzrz*). The *Rz*

gene, conferring resistance to BNYVV, did not confer resistance to BSBMV. *P. betae* alone had a significant negative effect on growth of sugar beet in greenhouse pot cultures. BSBMV ELISA values were significantly higher in single infections than in mixed infections with BNYVV, in both the rhizomania-resistant and susceptible varieties. In contrast, ELISA values of BNYVV were high (8 to 14 times the healthy mean) in single and mixed infections in the rhizomania-susceptible variety, but were low (ca. three times the healthy mean) in the rhizomania-resistant variety. Therefore, in the absence of BNYVV, ELISA values for BSBMV are high, regardless of the resistance genotype. In the presence of BNYVV, however, BSBMV ELISA values are low in both resistant and susceptible varieties with absorbance ($A_{405\,nm}$) readings similar to those of plants grown in non-infested soils. BNYVV may suppress BSBMV in mixed infections, even in rhizomania-resistant varieties in which ELISA values for BNYVV are extremely low. Soils infested with *P. betae*, and with one or both viruses, showed significantly reduced fresh weight of seedlings.

YU, M.H. 2003. <u>Developing Sugarbeet with Resistance to *Meloidogyne* Spp.</u> Proceedings Int. Congr. Genetics 19: In press.

Root –knot nematodes (*Meloidogyne* spp.) are important sugarbeet (*Beta vulgaris* L.) pathogens that are difficult to control. Host-plant resistance was discovered from rare strains of the wild beet, *B.vulgaris* ssp. *maritima*. The resistance is effective against multiple species and races of nematode belonging to the genus *Meloidogyne*, based on J2 inoculation tests. Incorporation of resistance to root-knot nematode into sugarbeet was carried out through hybridization and back-crossing to sugarbeet in the greenhouse. Selection against annual bolting, disease susceptibility, and root morphology was done from field plantings. the intensity of sprangled root structures and easy bolting habits decreased with selection pressure and as the number of breeding generations progressed. Promising sugarbeet plants with stable resistance transmission and improved taproot conformation eventually developed. Two series of root-knot nematode resistant sugarbeet genotypes, Mi-1 and M66, were generated. From these sources several *Beta* germplasm lines with resistance to *Meloidogyne* spp. have been developed and released.

YU, M.H. 2003. <u>Development of Root-Knot Nematode-Resistant Sugarbeet.</u> Proceedings IIRB Congress 66: In press.

Sugarbeet, *Beta vulgaris*, is a favored host of *Meloidogyne* spp. Host-plant resistance to multiple species of root-knot nematodes was not found in the cultivated sugarbeet but was identified from wild *maritima* beets. The resistance has been introgressed into sugarbeet genotypes. Several breeding populations were planted in heavily infested field plots. Preliminary evaluations indicated that about 77% of plans in resistant families and 44% in backcrossed populations, produced healthy roots while the rest were with gall symptoms. In comparison, none of the susceptible control plants were free from galling; one-third of them died. Positive results were demonstrated by the improved taproot conformation and root weights. A phosphoglucomutase (PGM) isozyme marker for Mi-1 *Beta* and cleaved amplified polymorphic sequence (CAPS) marker for M66 *Beta* were recently identified. The use of marker-assisted selections may

facilitate sugarbeet root-knot nematode resistance breeding. Additional improvements on the breeding materials are needed to develop an elite sugarbeet cultivar.

YU, M.H. 2003. Registration of Root-knot Nematode-Resistant Sugarbeet Germplasm M6-2. Crop Sci. 43: In press.

M6-2 was produced by inter-pollinating more than 30 plans selected from the fifth backcross generation progeny of hybrids between M66 (PI 586688) and cultivated sugarbeet lines, including C37 (PI 590715). From the F_1BC_5 generation, individual plants with root-knot resistance were selected and intercrossed. Plants from this F_2FC_5 generation were selected for nematode resistance and individually test crossed to a susceptible sugarbeet. Based on the information from these test cross families, individual F_2 plants that had been retained and appeared to be homozygous for resistance were intercrossed to produce M6-2 line. due to its wild beet ancestry M6-2 sugarbeet plants often expressed various levels of sprangled root traits. M6-2 is highly resistant, if not immune, to root-knot nematode. M6-2 is a multigerm, biennial, self-incompatible sugarbeet germplasm that is heterogeneous for plant type and hypocotyl color. Approximately 75% of the seedlings have nongreen hypocotyls. The M6-2 germplasm is resistant to multiple species of root-knot nematode, including *M. incognita*, etc. The level of resistance to root-knot nematode in M6-2 appeared to be similar to M6-1 (PI 613165), the first generation backcross progeny of M66. However, M6-1 is a self-compatible line with green hypocotyls, and its taproots exhibit a heavier sprangled trait in comparison to M6-2.

YU, M.H. and R.T. LEWELLEN. 2002. Registration of Sugarbeet Germplasm M1-3 Resistant to Root-Knot Nematode. Crop Sci. 42(5):1756-1757.

The initial seed of M1-3 was produced by inter-pollinating more than 60 plants selected from the fourth backcross generation of hybrids between wild beet (*B. vulgaris* ssp. *maritima*) line M1-2 (PI 614899) and recurrent sugarbeet parents, C37 (PI 590715), C69 (PI 599-341), and C78 (PI 593671). These selected plants all produced root-knot resistant progeny, when crossed to susceptible sugarbeet, as determined by J2 larval inoculation studies in the greenhouse. M1-3 is highly resistant, if not immune, to root-knot nematode. M1-3 is a multigerm, biennial, self-incompatible sugarbeet germplasm that is heterogenous for plant type and hypocotyl color. Approximately 80% of the seedlings have nongreen hypototyls. Taproot size and conformation is not as uniform as its recurrent parents; however, the intensity of the sprangled root growth habit of M1-2 has been greatly decreased. The M1-3 germplasm is resistant to several species of root-knot nematode, including *M. incognita, M, javanica, M. arenaria, M. hapla, M. chitwoodi,* and *M. fallax.*

The strength of resistance to root-knot nematode in M1-3 is similar to that of M6-1 (PI 613165), but the two germplasms can be differentiated by a phosphoglucomutase (PGM) isozyme stain on starch gels. F_1 progeny of M1-3 produce the PGM banding pattern associated with root-=knot nematode resistance. However, a similar banding pattern has not been observed in M6-1 or its progeny. In addition, M6-1 is self-compatible, but M1-3 is self-incompatible.

YU, M.H. and P.A. ROBERTS. 2002. <u>Selection of root-knot nematode resistant sugarbeet from field plantings</u>. Nematology 4:240.

The resistance to root-knot nematode was identified seven years ago, and since then it has been introgressed into cultivated sugarbeet. Preliminary observations on several breeding populations were conducted in field plots infested with either *M. incognita* or *M. javanica* at U.C. Research and Extension Centers, Irvine and Parlier, California. In resistant progeny families, more than 50% of the plans produced healthy taproots that exhibited no root-knot symptoms. In comparison, none of the susceptible control plants were free from galling. Significant reductions of approximately 45% or more in root weights occurred when there susceptible control plants were grown in infested soil. Susceptible sugarbeet suffered a higher sensitivity reaction to prolonged temperature (>38°C) stresses and secondary pathogenic invasions than the resistant counterpart. Greenhouse inoculation screenings provided reliable classification of resistant genotypes, but no index of full growth potential of the plants. Our results indicate that a productive root-knot nematode-resistant sugarbeet line with elite root yield, taproot conformation, and sucrose content would be developed more readily when resistant parents were grown and selected from nematode infested fields.

Project 260

ETIOLOGY AND EPIDEMIOLOGY STUDY OF NEW BEET-INFECTING VIRUSES IN THE UNITED STATES

Hsing-Yeh Liu, John L. Sears, and Robert T. Lewellen
USDA-ARS, Salinas, California

SUMMARY

In rhizomania infested fields, sugar beet leaves with oak-leaf pattern symptoms different from rhizomania were found in California. A virus with rigid rod-shaped particles was isolated. For purposes of discussion this unknown virus was designated Beet oat-leaf virus (BOLV). BOLV is serologically distinct from *Beet necrotic yellow vein virus* (BNYVV), *Beet soil-borne mosaic virus* (BSBMV), and *Beet soil-borne virus* (BSBV). The host range of BOLV is similar to BNYVV and BSBMV mostly infecting *Chenopodiaceae* plants. BOLV produces chlorotic local lesions with a necrotic ring after mechanical inoculations. Particles were about 20 nm wide and ranged from 80 to 640 nm with three modal lengths: 180-200 nm, 260-280 nm, and 300-320 nm. *Polymyxa betae* transmission of BOLV was demonstrated through a bioassay by using BOLV-infected cystosori and sugar beet as bait. BOLV has been purified from *Spinacia oleracea*. The molecular mass of the capsid protein was estimated to be 46.0 kDa. A polyclonal antibody from rabbits has been produced and can be used in ELISA, western blot, and immunogold labeling tests. BOLV appears to be wide spread in U.S. It has been found also in Colorado, Michigan, Minnesota, Nebraska, and Wyoming. BOLV was found in sugar beet alone or co-infected with BNYVV and/or BSBMV. The economic significance of BOLV and its interaction with other furoviruses are not known.

INTRODUCTION

During the survey for rhizomania disease, an unnamed virus showed oak-leaf pattern symptoms on sugar beet (Fig. 1) was found in California. A virus with rod-shaped particles was isolated in addition to *Beet necrotic yellow vein virus* (BNYVV), the causal agent of rhizomania. This unnamed virus of sugar beet is tentatively called Beet oak leaf virus (BOLV). BOLV and BNYVV serologically are distinct. Taproots of beets infected with BOLV often appear healthy, unlike those of beets infected with BNYVV. The objectives of this study are to determine some of the physical, biological, and serological characteristics of BOLV.

Fig. 1. *Beta vulgaris* infected with Beet oak-leaf virus showing oak-leaf pattern symptoms.

MATERIALS AND METHODS

Symptomatic field sugar beet leaves were ground in 0.1 M phosphate buffer, pH 7.0, and mechanically inoculated to *Chenopodium quinoa* Willd. Each single local lesion was subinoculated to *C. quinoa*. The local lesions were freeze dried for virus source. In host range tests, the selected host plant species were mechanically inoculated as above.

BOLV was purified from *Spinacia oleracea*. Infected spinach plants were homogenized with two volumes of 0.1 M phosphate buffer and clarified with 1/2 volume of carbon tetrachloride. Virions were precipitated with 6% polyethylene glycol (mol. wt 6,000) and 0.2 M sodium chloride. The virions were further purified and concentrated by two cycles of differential centrifugation, followed by centrifugation through a 10-35 % sucrose density gradient. Purified virus particles were analyzed by SDS-PAGE to determine the molecular mass of the capsid protein.

Antiserum to the purified virions was prepared in New Zealand white rabbits. Freund's complete adjuvant and 500 μg of purified virus were used for the first injection and incomplete adjuvant with 250 μg of virus was used in four subsequent injections. The double antibody sandwich (DAS)-ELISA, Western blot procedure, and immunoelectron

A21

microscopy technique were conducted essentially as described in the literatures (Clark and Adams, 1977, Towbin, et al, and Lin, 1984).

BOLV infested soil or BOLV infected *Polymyxa betae* cystosori in sugar beet roots were air-dried for 3 weeks to provide inocula for transmission tests. The air-dried roots were ground to a fine powder and mixed with pasteurized potting soil. Sugar beet seeds were added to the pots and covered with pasteurized sand. The pots were kept in insect-proof greenhouse and temperature controlled at about 80 F for 40 to 50 days. Plants were then harvested, tested for BOLV using DAS-ELISA and microscopic examination for *P. betae*.

RESULTS

In host range tests, 15 species of 5 families were mechanically inoculated. *C. amaranticolor, C. murale,* and *C. quinoa* showed local lesions and *Beta macrocarpa, B. vulgaris, Spinacia oleracea, Nicotiana benthamiana* and *Tetragonia expansa* produced systemic infection.

In both soil testing and *P. betae* transmission tests sugar beet roots were positive for BOLV in ELISA tests and *P. betae* was found in the infected roots under light microscope. BOLV was recovered by mechanical inoculation to *C. quinoa* plants.

Purified virions were rigid rod-shaped particles with a central canal (Fig. 2). More than 350 virus particles were measured in the leaf dip preparations (Liu, et al, 2000). The virus particles were about 20 nm wide and of three predominant lengths, 180-200 nm, 260-280 nm, and 300-320 nm (Fig.3). The virus particles were capsided by single protein subunits of 46.0 kDa (Fig. 4). The antisera to BOLV produced from purified virions were specific to BOLV in DAS-ELISA (Table 1) and western blot analyses. BOLV-infected plants were successfully identified by immunogold labeling in leaf dips (Fig. 5).

Table 1. Serological relations of Beet oak-leaf virus and other *Polymyxa betae* transmitted beet viruses using DAS-ELISA

Antigen/Antiserum	BOLV	BNYVV	BSBMV	BSBV	TMV
BOLV	+	-	-	-	-
BNYVV	-	+	-	-	-
BSBMV	-	-	+	-	-
BSBV	-	-	-	+	-
TMV	-	-	-	-	+
Healthy CK	-	-	-	-	-
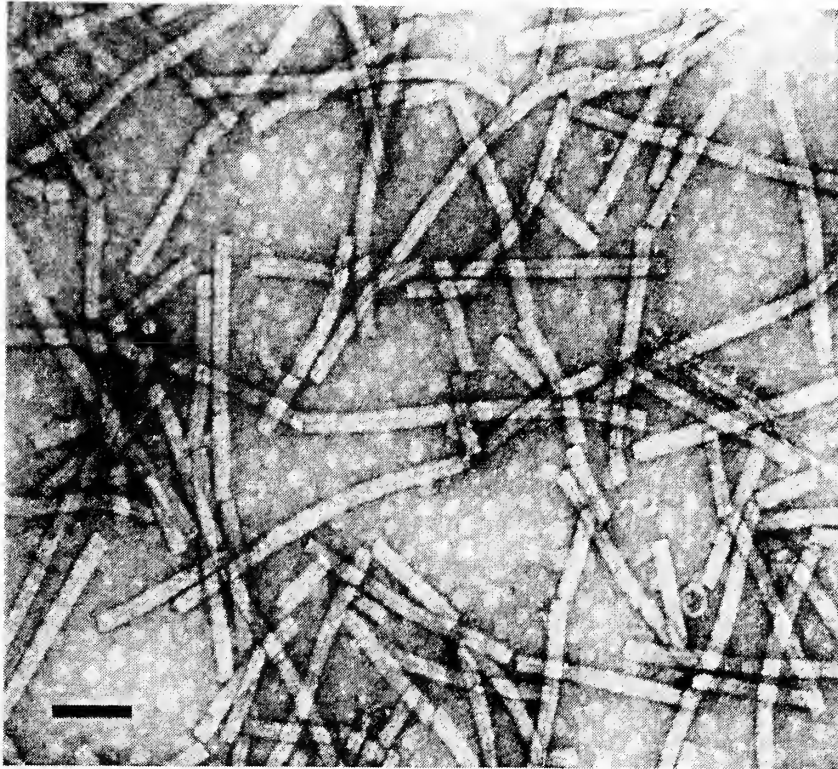
Fig. 2. Purified Beet oak-leaf virus particles are straight, rod-shaped with a central canal. The bar represents 100 nm.

Fig. 3. Particle Length Distributions of Beet Oak-Leaf Virus in Leaf Dip Preparations
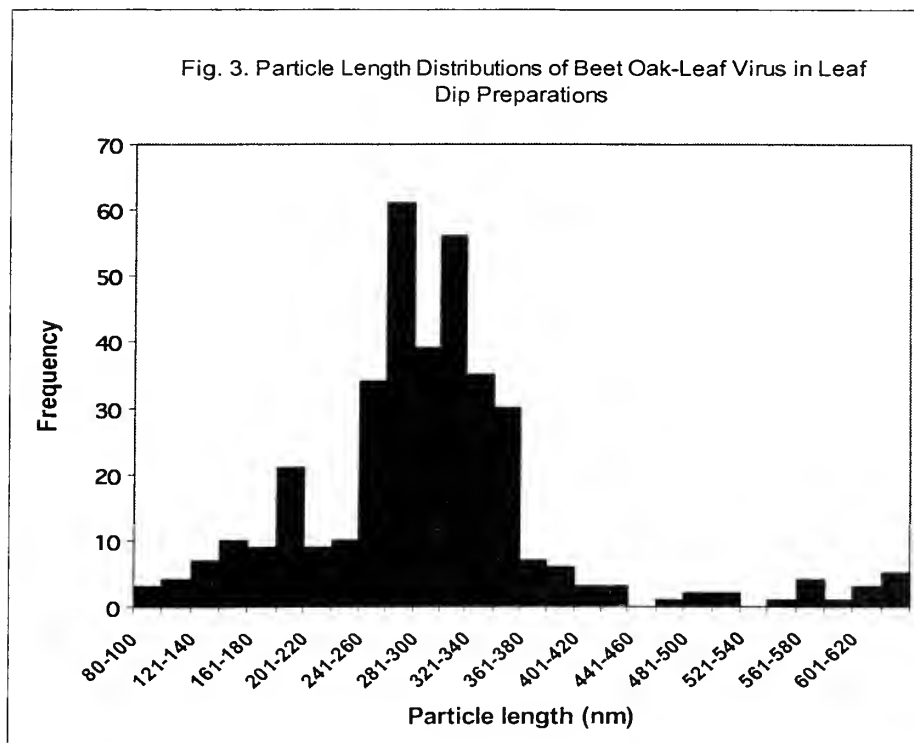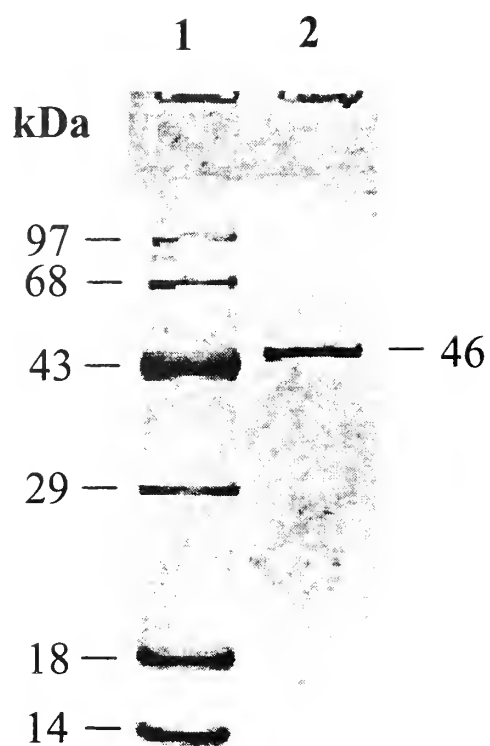
Fig. 4. Sodium dodecyl sulfate-polyacrylamide (12% acrylamide) slab gel showing virion capsid protein. Lane 1, molecular weight standards in order of decreasing mass: phosphorylase B, bovine serum albumin, ovalbumin, carbonic anhydrase, B-lactoglobulin, and lysozyme. Lane 2, Beet oak-leaf virus.

Fig. 5. Immunoelectron microscopy. BOLV-anti-BOLV followed by gold-IgG complexes, showing a direct association of virus particles and labelled gold-IgG complexes.

CONCLUSIONS

BOLV was isolated from sugar beet leaves with oak-leaf pattern symptoms from a rhizomania field in California. Like BNYVV, it causes local lesions on *C. quinoa*, but those of BOLV always had a necrotic ring surrounding the chlorotic local lesions. In the later stages, all lesions became large irregular shaped necrotic lesions. Systemic infection of *C. quinoa* were not observed. BOLV was difficult to pruify, probably because it is unstable in vitro, tends to aggregate during purification, and/or occurs within plants in low concentration; nevertheless, an antiserum was obtained with partially purified virus preparations. BOLV antiserum was specific and can be used in ELISA tests, Western blots, and immunoelectron microscopy. BOLV coat protein molecular weight was estimated at 46.0 kDa. The reported molecular weight of BNYVV coat protein is 22 kDa and BSBMV is 24 kDa (Wisler, G. et al, 1994). BOLV was distinct from beet infecting benyviruses serologically. It was also distinct from *Beet virus Q* biologically (Koenig, R. et al, 1998), e.g. symptom expression on *C. quinoa* and systemic infection on *N. benthamiana*.

BOLV seems to be a multiparticulate virus, made up of 3 particles. The molecular weight of BOLV RNAs has not yet been determined. Whether BOLV belongs to benyvirus or other fungal-transmitted rod-shaped viruses will require additional study.

REFERENCES

Clark, M. F., and Adams, A. N. (1977). Characteristics of the microplate method of enzyme-linked immunosorbent assay for the detection of plant viruses. J. Gen. Virol. 34, 475-483.

Koenig, R., Pleij C. W. A., Beier, C., and Commandeur U. (1998). Genome properties of beet virus Q, a new furo-like virus from sugarbeet, determined from unpurified virus. J. Gen. Virol. 79, 2027-2036.

Lin, N.-S. (1984). Gold-IgG complexes improve the detection and identification of viruses in leaf dip preparations. J. Virol. Methods 8, 181-190.

Liu, H.-Y., Wisler, G. C., and Duffus, J. E. (2000). Particle length of whitefly-transmitted criniviruses. Plant Dis. 84, 803-805.

Towbin, H., Staehelin, T., and Gordon, J. (1979). Electorphoretic transfer of proteins from polyacrylamide gels to nitrocellulose sheets: Procedure and some applications. Proc. Natl. Acad. Sci. USA 76, 4350-4354.

Wisler, G. C., Liu, H.-Y., and Duffus, J. E. (1994). Beet necrotic yellow vein virus and its relationship to eight sugar beet furo-like viruses from the United States. Plant Dis. 78, 995-1001.

Project 281

Evaluation of the effect of synergism between BNYVV and BSBMV on resistance to these viruses in sugarbeet

William M. Wintermantel and Robert T. Lewellen
USDA-ARS, Salinas, California

INTRODUCTION:

Rhizomania is now present in all areas of the United States where sugarbeet is grown (Wintermantel et al., 2003). This disease is caused by *Beet necrotic yellow vein virus* (BNYVV), a benyvirus transmitted by the soil-borne fungus *Polymyxa betae*. All BNYVV isolates from soils in the U.S. are identical, based on: (1) studies of the responses of susceptible host plants; (2) serological relatedness of the coat protein and several nonstructural proteins; (3) the number and size of the RNAs in each isolate; (4) and the relationship of each RNA on a molecular level compared to a European isolate of BNYVV. This American BNYVV isolate was probably introduced from Europe, where multiple isolates exist, and has since spread throughout North America. *Beet soil-borne mosaic virus* (BSBMV) and other non-BNYVV soil-borne viruses are often present in beet plants that are also infected with BNYVV. Although BSBMV is not the only one of these viruses, it is the best characterized, and results of interactions between BSBMV and BNYVV may be representative of interactions between benyviruses in general. All BSBMV isolates are serologically identical to one another, but differ in host response and the number and size of viral RNAs. This pattern is indicative of a virus which originated and has evolved in North America. None of the BSBMV isolates cause the root proliferation characteristic of Rhizomania disease and BNYVV infection, but our studies indicate that BSBMV isolates do reduce growth of beets (Wisler et al., 2003).

Several control measures have been established for rhizomania. These have been developed over several years of research by pathologists and breeders, and include: (i) avoidance of infested fields by testing soil for the presence of *Beet necrotic yellow vein virus* (BNYVV) prior to planting, (ii) early planting into cool soils, (iii) soil fumigation where allowed, and (iv) use of resistant cultivars. These measures apply to all soil-borne, fungus-transmitted viruses of sugarbeet, including BNYVV, *Beet soil-borne mosaic virus* (BSBMV), *Beet soil borne virus* (BSBV), and others. Viruliferous *P. betae* (*P. betae* containing virus) remains in soil after harvest and can survive for many years. It is important, therefore, to decrease levels of virus inoculum in the soil by whatever means possible. The most cost-effective and successful control measure for growing beets in infested soil is the use of resistant varieties. Many sugarbeet cultivars have now been bred with varying degrees of resistance to rhizomania. Resistant varieties are not immune to BNYVV, but do reduce virus accumulation and disease severity. Current resistant varieties now yield nearly as well as non-resistant varieties in the absence of rhizomania disease pressure.

Over the past several years, both sugar and tonnage were decreased in Great Plains beet growing regions. Several causes have been attributed to this problem including *Cercospora* leafspot, *Rhizoctonia*, root aphids, root maggots, BSBMV, and rhizomania (caused by BNYVV) to name a few. Although rhizomania was initially blamed for the low yields, repeated tests from labs at the University of Nebraska in Scottsbluff were negative for BNYVV. Results from previous studies by our laboratory in Salinas suggest that BSBMV, in particular, may be important in the yield losses. One of the most significant findings from our initial studies on the yield decline was that 24 of 27 soils tested, showing the decline in sugarbeet production were infested with either BSBMV, BSBV, or both. Only 2 of the soil samples were positive for BNYVV, and one of these was a soil which had been submitted as a rhizomania positive control. Although the effects of Rhizomania were well known on sugarbeet, much less was known about the effects of BSBMV or BSBV on beets. It was suspected that these viruses, either alone or in combination, contributed to a yield loss in sugarbeet. Studies conducted in our greenhouses in Salinas examined soils infested with BNYVV, BSBMV, both viruses, and virus free *P. betae*, as well as virus and vector-free soil. The results of these studies, discussed in the *Sugarbeet Research 2001 Report*, identified two problems that significantly reduced sugarbeet growth, compared with non-inoculated control plants. Beets grown in soil infested with both BSBMV and BNYVV were sometimes stunted much more severely than those grown in soil infested with either virus alone. In addition, *P. betae*, with or without virus had a significant effect on beet growth. Studies on virus concentration in infected plants demonstrated that BNYVV is more competitive in sugarbeet than BSBMV, suppressing BSBMV concentrations in infected tissue during mixed infection in greenhouse tests (Wisler et al., 2003).

Compared with BNYVV, much less is known about the effects and importance of other *P. betae* vectored viruses in the rhizomania disease syndrome. Knowledge that has been generated on BNYVV, however, can often be applied to the study of other soil-borne sugarbeet viruses, including BSBMV. BSBMV is the best characterized non-rhizomania causing benyvirus known, and information gained on BSBMV and its interactions with BNYVV may provide insights into interactions of other related viruses with BNYVV, as well. Our greenhouse studies in Salinas have shown that BSBMV can have a significant effect on growth of sugarbeet, whether alone or in combination with BNYVV. Recently completed research by our lab demonstrated that BNYVV and BSBMV, as natural mixed infections from infested soil, can have a significantly greater detrimental effect on beet growth than either virus alone (Wintermantel et al., 2001; Wisler et al., 2003). This recent finding has led to a number of additional challenges. We need to determine what effect non-BNYVV furoviruses (now collectively called *Benyviruses* for <u>Be</u>et <u>n</u>ecrotic <u>y</u>ellow <u>v</u>ein <u>v</u>irus; Torrance and Mayo, 1997) have on field production of sugarbeet. Secondly, can we identify sources of resistance to BSBMV. We need to concentrate our efforts on: (1) characterizing the nature of the interactions between BNYVV and BSBMV, and (2) take advantage of the decreased severity of BSBMV (in single infections) to determine what viral genetic differences are responsible for converting a relatively mild virus (BSBMV), into a highly damaging virus (BNYVV). This may ultimately lead to an opportunity to develop targeted strategies for preventing BNYVV symptom expression and possibly replication in sugarbeet.

The presence of multiple soil-borne viruses in the same fields will likely lead to virus interactions in sugarbeet plants and the synergism described above that can result in further yield decreases. Our research is working toward determining not only how these interactions affect sugarbeet, but more importantly, toward identifying beet varieties with better performance under

conditions of mixed infection. These results should benefit the entire sugarbeet industry, through improved performance in the presence of mixed infection.

PROJECT ACCOMPLISHMENTS (CUMULATIVE):

1. The TAS-ELISA test modified for BNYVV in our studies gave no background cross-reactions with other soil-borne viruses of sugarbeet, in particular, isolates of BSBMV. One isolate each of BSBMV from Texas and Minnesota gave reactions equivalent to those of healthy sugar beet roots and healthy leaf tissues of *B. macrocarpa*. In addition, serial dilution studies with the BNYVV antiserum demonstrated that variation in BNYVV content among resistant and susceptible sugarbeet varieties can be detected. The BNYVV antiserum developed in Salinas has become the standard for detection of BNYVV and has been licensed to Agdia for commercial availability.
2. ELISA tests were used to determine levels of BNYVV among eight sugarbeet varieties. Differences in absorbance (A405 nm) values closely corresponded to a gene dosage effect, specifically to the frequency of the Rz allele that conditions resistance to BNYVV. This demonstrated differential expression of Rz resistance alleles. Differences in BNYVV levels were observed among harvest dates, with progressively lower absorbance values measured as the season progressed. This pattern held true for all cultivars.
3. Absorbance values were significantly positively correlated with rhizomania disease index scores and negatively correlated with individual root weight, plot root weight and sugar yield. These results are important in plant breeding, variety development, and cultivar evaluation. They show that the breeder or agronomist can be fairly confident of measuring varietal reactions to rhizomania by either scoring or weighing field grown material. Root weights and visual scoring are usually made more easily in a breeding or testing program than absorbance measurements from ELISA tests. This information is useful in resistance breeding and evaluation programs and for the sugar industry in consideration of cultivar choice, inoculum production and rotations for future cropping.
4. Eight sugarbeet cultivars, that range in reaction to rhizomania from uniformly susceptible to highly resistant, were compared for levels of BSBMV. Infections were established by growth in soil infested with viruliferous *Polymyxa betae*. All cultivars were highly susceptible to BSBMV, with absorbance readings ranging from 8 to 12 times the healthy root mean. In current studies, when mixed infections of BNYVV and BSBMV were compared to single infections in both a susceptible and resistant sugarbeet line, the reactions, as measured by root symptoms and individual beet weight were significantly more severe than for each virus alone. This was true regardless of whether the seedlings were initially grown in soil infested with either BNYVV or BSBMV. Thus, resistance to BNYVV does not confer resistance to BSBMV, nor does BSBMV infection moderate the effects of BNYVV.
5. BSBMV levels were significantly decreased by the presence of BNYVV in both BNYVV-resistant and susceptible varieties grown in soil infested with both viruses compared with singly infested soils. In contrast, BNYVV levels were either unaffected or increased in the presence of BSBMV. This demonstrated that interactions between soil-borne viruses significantly affect virus accumulation and disease severity in sugarbeet.

OBJECTIVES FOR 2002-2003:

1. Differentiate variety reactions to BSBMV among both representative commercial hybrids, sugarbeet breeding lines, and germplasm resources to identify potential sources of resistance to BSBMV.

2. Evaluate representative sugarbeet varieties for yield effects and relative concentrations of virus following growth in soil infested with BNYVV alone, or soil infested with both BNYVV and BSBMV to determine performance under pressure from virus synergism.

3. Examine the effect of BSBMV alone on sugarbeet growth and virus concentration under field conditions through studies conducted in isolation plots.

4. Assemble small clones generated during sequencing the genome of the Texas 7 isolate of BSBMV (Lee and Rush, 2001) into full-length infectious clones that can be used in future studies to determine why BSBMV does not elicit the hairy root symptoms characteristic of BNYVV (rhizomania) on sugarbeet roots. The information gained may ultimately lead to new control strategies for BNYVV and other soil-borne viruses.

ACCOMPLISHMENTS AND RESULTS (CURRENT YEAR):

Both *objectives 1 and 3* were addressed in studies conducted in microplots. This was a change from initial plans, but one that streamlined the project, and provided screening for resistance, as well as testing under field conditions simultaneously. Microplots are small, contained research plots that were constructed at the USDA-ARS Research Station in Salinas. Plots contained *P. betae* and BSBMV, for the specific purpose of identifying resistance to BSBMV in sugarbeet germplasm. Separate plots were developed and provided with virus-free soil for use as controls. Each plot type was present in triplicate for replication. These plots were tested in the spring/summer of 2002 for disease incidence and found to produce consistent, uniform BSBMV infections. Resistance tests were conducted in the summer and fall with 8 varieties of segregating germplasm tested. R.T. Lewellen provided sugarbeet seed from the USDA-ARS germplasm collection in Salinas for these studies. Seed was grown under field conditions in plots infested with *P. betae* and BSBMV, or non-infested soil for 2 months. At the end of this period, beets were assayed individually for BSBMV accumulation using ELISA with BSBMV specific antiserum. Plants were also tested with BNYVV antiserum to be certain no cross-contamination with BNYVV was present in these initial tests. BSBMV infections developed well in test plots, while virus-free plots did not have any incidence of BSMBV. No cross-contamination with BNYVV was detected.

Analysis of 2002 tests suggests BSBMV resistance may be present in some germplasm sources, but further testing will be necessary (Table 1). Varieties of European origin appear to exhibit the least resistance (Beta4430 and Beta6600). This is not surprising, as incidental selection for BSBMV resistance would not have occurred in Europe, since the virus is not present there. Most other lines tested had lower levels of virus accumulation and lower percents infection, suggesting partial BSBMV resistance may be present in a number of these sources. Line 9933, which

performed better than all other lines (Table 1), was developed in Salinas, but incorporates germplasm selected over time in Colorado, where BSBMV is prevalent. Analysis of plant weight was not presented, as numbers were not meaningful. This information will be meaningful only after identification of varieties with decreased virus accumulation, and particularly during studies on mixed infection. A number of additional sugarbeet lines remain to be tested during the summer of 2003. Most lines being screened are segregating, such that some plants may be resistant while others are not, even from the same seed lot. As a result, it is necessary to look at averages as an indication of performance. As varieties with good performance are identified, these will be selected and used to develop stable resistance to BSBMV, which can then be combined with resistance to BNYVV.

During this first year of studies to identify and develop varieties with resistance to both BSBMV and BNYVV, we have not yet evaluated the effect of mixed infection on performance of resistant varieties (*Objective 2*). This objective has been delayed due to the need to identify sources of resistance to BSBMV. It is critical to the success of this project that BSBMV resistance be identified first, followed by subsequent testing of BSBMV resistant material under conditions of mixed infection. This is necessary, since mixed infection by both viruses results in competition between the viruses in sugarbeet, and this competition may affect performance of resistant material (see project 281 report for 2001; Wisler et al., 2003). By identifying BSBMV resistance first, competition effects are avoided, BSBMV resistance sources can be identified, and this material can be used in breeding for combined resistance against both BSBMV and BNYVV. After completion of the analysis of varieties for resistance to BSBMV alone, BSBMV microplots will be converted to mixed infection by addition of BNYVV inoculum, and these plots can then be used to test varietal performance under conditions of mixed infection. Ultimately, we intend to provide putative BSBMV resistance sources for commercial trials in areas where mixed infection occurs, to determine performance of these varieties in the field. Field trials, however, are probably at least two years away.

Table 1. BSBMV accumulation and percent infection among sugarbeet Germplasm evaluated in summer 2002.

Variety	ELISA (A405nm)[1]	Percent Infection[2]
Beta 4430R	0.47	76%
Beta 6600	0.43	67%
9933	0.33	44%
Y207-8	0.34	56%
01-FC1030	0.34	61%
R221	0.36	56%
Y169	0.38	61%
Y275	0.38	78%

1. Mean absorbance at 405nm as measured by enzyme-linked immuno-sorbent assay (ELISA) using antiserum specific for BSBMV.
2. Percent infection is based on the number of plants infected with BSBMV / number tested. Plants are considered positive when ELISA readings with BSBMV antiserum are 3 times the value of healthy controls.

Objective 4: Partial clones of BSBMV were provided by Dr. Lawrence Lee, formerly of the Texas Agricultural Experiment Station, Bushland, TX with C.M. Rush (Lee et al., 2001). Partial clones are being assembled into full-length BSBMV RNAs using RT-PCR with a high fidelity DNA polymerase. For areas of the genome where clones were not available, viral RNA is being purified from plant material and used for RT-PCR based cloning. Complete full-length clones of BSBMV RNAs 3 and 4 have been constructed. Large, partial clones of RNAs 1 and 2 (which are much larger) have been constructed this year, and complete full-length clones of these two larger RNAs are expected within the year. Full-length clones of individual BSBMV RNAs are being placed in transcription vectors for expression of RNA that can be used to inoculate plants and determine infectivity. Infectivity of individual full-length clones will be confirmed by co-inoculation of RNA produced *in vitro* to susceptible host plants, including sugarbeet. Once completed, these clones will be valuable for determining why BSBMV does not elicit the hairy root symptoms characteristic of BNYVV (rhizomania) on sugarbeet roots, and differences in virus accumulation and movement of these viruses in sugarbeet. They will also allow direct studies to determine how mixed infection by benyviruses may affect evolution of these viruses (which may impact stability of resistance). The information gained may ultimately lead to new control strategies for BNYVV and other soil-borne viruses.

REFERENCES:

Lee, L. Telford, E.B., Batten, J.S, Schlothof, K.-B.G., and Rush, C.M. 2001. Complete nucleotide sequence and genome organization of Beet soilborne mosaic virus, a proposed member of the genus Benyvirus. *Arch. Virol.* 146:2443-2453.

Torrance, L. and Mayo, M. S. 1997. Proposed reclassification of Furoviruses. *Arch. Virol.* 142:435-439.

Wintermantel, W.M., Wisler, G.C., Lewellen, R.T., Liu, H.-Y., and Sears, J. 2001. Interactions between BNYVV and BSBMV in sugarbeet affect virus titer and beet development. *Phytopathology* 91: S150.

Wintermantel, W.M., Crook, T., and Fogg, R. (2003). First report of rhizomania disease of sugar beet caused by *Beet necrotic yellow vein virus* in the Great Lakes production region. *Plant Disease* 87(2): 201.

Wisler, G.C, Lewellen, R.T., Sears, J.L., Wasson, J., Liu, H.-Y. and Wintermantel, W.M. 2003. Effects of *Beet necrotic yellow vein virus* (BNYVV), *Beet soil-borne mosaic virus* (BSBMV) and their fungal vector, *Polymyxa betae*, on virus levels and sugarbeet growth. *Plant Disease* (submitted).

DEVELOPMENT OF SUGARBEET BREEDING LINES AND GERMPLASM

R.T. LEWELLEN

CP03, CP04, CP05, & CP06 – CP03 (PI632284) and CP04 (PI632285) are multigerm, self-sterile, germplasm lines that segregate for resistance to powdery mildew (*Pm*) caused by *Erysiphe polygoni* and rhizomania (*Rz*) caused by *Beet necrotic yellow vein virus*. CP03 and CP04 have identical developmental histories except for the *Beta vulgaris* subsp. *maritima* source of resistance to powdery mildew. Resistance within CP03 is from WB97 (PI546394) and CP04 is from WB242 (PI546413). Up through the FC_3F_1 generation, CP03 was the same as CP01 (PI610490) and CP04 as CP02 (PI610491). For the fourth backcross, C78/3 (PI628752) was used. For backcrosses five and six, C37 (PI590715) was again used as the recurrent parent. CP03 and CP04 would have approximately 87% of their germplasm from C37, 12% from C78, and 1% from the wild beet source of resistance to powdery mildew. Starting from BC_4F_1 generations, in general, individual plans were selected from the backcross families for resistance to powdery mildew and rhizomania and pair crossed under paper bags in the greenhouse to the recurrent parent. For the BC_6F_1 families, individual pair crosses were evaluated in the field at Salinas in a March planting under natural powdery mildew and rhizomania infected conditions. Individual plants from within these families were selected in November for high resistance to powdery mildew, resistance to rhizomania, and for nonbolting. Within each source of resistance set of families, selected plants were combined and increased in mass to produce BC_6F_2 populations released as CP03 and CP04. CP03 is from seed lot P227 and had been developed and tested as lines P127, P027, P917, and P815. CP04 is from seed lot P228 and had been developed and tested as lines P128, P028, P918, and P816. Other than for powdery mildew and rhizomania, theoretically, diseased resistance and agronomic traits of CP03 and CP04 should be similar to C37, but, in the BC_6F_1 families, obvious, visual difference were evident. Segregation for annualism and *B.v.* subsp. *maritima* coloring patterns still occurred. In addition, in tests in Brawley, CA, CP04 showed higher resistance to rhizomania under high temperature conditions than CP03 or C78/3 and appeared to be tolerant to phytotoxemia from the feeding of *Empoasca* leafhoppers retaining its canopy longer in a full, dark greed condition. CP03 and CP04 should be useful as enhanced sources of resistance to powdery mildew found in *B.v.* subsp. *maritima* and for genetic and plant pathological research.

CP05 (PI632286) and CP06 (PI632287) are multigerm, self-sterile, germplasm lines that segregate for resistance to powdery mildew (*Pm*) caused by *Erysiphe polygoni* and rhizomania (*Rz*) caused by *Beet necrotic yellow vein virus*. CP05 and CP06 have identical developmental histories except for the *B.v.* subsp. *maritima* source of resistance to powdery mildew. Resistance within CP05 is from WB97 and CP06 is from WB242. Up through the BC_3F_2 generation, CP05 was the same as CP01 (PI610490) and CP06 was CP02 (PI610491). From the fourth backcross through backcross seven, the recurrent parent for CP05 and Cp06 was C78/3 (PI628752). Usually, the lines were advanced from seed produced on C78/3 or from reciprocal pairs that had identical appearance in field plots. Starting from the BC_3 generations, in general, individual plans were selected from the backcross families for resistance to powdery mildew and

rhizomania and pair crossed under paper bags in the greenhouse to C78/3. For the BC$_7$F$_1$ families, individual pair crosses were evaluated in the field at Salinas in a March planting under natural powdery mildew and rhizomania infected conditions. Individual plans from within these families were selected in November for high resistance to powdery mildew, resistance to rhizomania, and for nonbolting. Within each source of resistance set of families, selected plants were combined and increased in mass to produce the BC$_7$F$_2$ populations released as CP05 and CP06. CP05 is from seed lot P229 and had been developed and tested as lines P129, P029, P919, and P809. CP06 is from seed lot P230 and had been developed and tested as lines P130, P030, P920, and P810. In addition to powdery mildew resistance conditioned by *Pm*, CP05 and CP06 likely have moderately high slow-mildewing type of resistance derived from C78/3 as compared to CP03 and CP04. The other disease resistance and agronomic traits of CP05 and CP06 should be similar to C78/3 but obvious visual difference still occurred. Up through BC$_7$F$_1$ families, annualism and coloring patterns of *B.v.* subsp. *maritima* lines WB97 and WB242 still occurred. CP05 and CP06 should be useful as enhanced sources of resistance to powdery mildew originally found in *B.v.* subsp. *maritima* and for genetic and plant pathological research.

Seed of CP03, CP04, CP05 and CP06 will be maintained at the USDA, ARS, U.S. Agricultural Research Station, Salinas, California, and will be provided upon written request to sugarbeet breeders in sufficient quantities for reproduction. Genetic material of these releases has been deposited in the National Plant Germplasm System where it will be available for research purposes, including development and commercialization of new parental lines and cultivars. It is requested that appropriate recognition be made if this germplasm contributes to the development of a new breeding line or cultivar. The National Germplasm System and additional information on prior releases and PI numbers can be found at: www.ars-grin.gov.

<u>CP07 & CP08</u> – CP07 (PI632288) is a multigerm sugarbeet (*Beta vulgaris* L.) line with high resistance to powdery mildew (*Pm*) and rhizomania, conditioned by *Rz* and factors from *Beta vulgaris* subsp. *maritima*. CP07 segregates for hypocotyl color and is likely self-sterile (S^sS^s) although segregation for self-fertility (S^f) is possible. In the bolted phase, CP07 segregates for determinate growth of stems. As far as is known, this is a previously undescribed morphological trait that causes the stem to abruptly end in a flower or cluster of flowers. On the bolted stems, most leaf axils have only flowers but not lateral branches. From one to many internodes are formed before stem stermination. As a line and in experimental hybrids CP07 shows moderate resistance to sugarbeet *Erwinia* and bolting tendency. It is intermediate for reaction to *Curly top virus*, similar to C78/3. It may show tolerance or have reduced infestation counts to sugarbeet cyst nematode (*Heterodera schachtii*) based upon field observations. At Salinas, in the absence of rhizomania, it has lower sugar yield and sucrose concentration than the mean of four commercial hybrid checks. Under rhizomania, it has higher sugar yield and equal sucrose concentration as these same rhizomania resistant checks. At Brawley, CA, under both rhizomania and nonrhizomania conditions, it had higher sugar yield and sucrose concentration than these rhizomania resistant commercial checks and other experimental lines and hybrids that depended solely upon the *Rz* factor for resistance to rhizomania. At Brawley, the late season survival and appearance score was superior to the above entries and similar to C927-4 (PI628756).

At Sainas in 1999 from three backcross families, 15 individual plants were selected. These mother roots were selected for resistance to rhizomania, high resistance to powdery mildew, and for nonbolting. Earlier in 1999, these same three backcross families were observed in the Imperial Valley of California to segregate for high resistance and survival to rhizomania under high temperature, severe rhizomania conditions. The recurrent parents leading to CP07 were C37 IPI590715), C72 (PI599342), and C78/3 (PI628752). The final two backcrosses were to C78/3. The donor parents had germplasm from *B.v.* subsp. *maritima* that contributed resistance to powdery mildew and rhizomania. It is estimated the CP07 has about 72% of its germplasm from C78/3, 24% from C37, 3% from *B.v.* subsp. *maritima* through C72 (PI599342) from C51 (PI593694), and 1% from both WB97 (PI546394) and WB242 (PI546413). Of the six parental plants in the final backcross, three plants were C78/3 and three had C51 germplasm in their background. Of the latter three plans, two also had germplasm from WB97 and one from WB242. It is believed that resistance to powdery mildew (*Pm*) was derived from WB97 and/or WB242 and resistance to rhizomania from C78/3 (*Rz*) and C51 and/or WB97 and WB242 for high resistance and survival under high temperature, severe rhizomania conditions. The 15 plants selected in 1999 were increased in mass in 2000 to produce P007/8. Line P007/8 was reselected in 2001 under natural powdery mildew, rhizomania, and cyst nematode infested conditions for resistance to powdery mildew and rhizomania and freedom from infestation with nematodes. Line P207/8 was released as CP07.

CP08 (PI632289) is a multigerm sugarbeet line with high resistance to powdery mildew, conditioned by *Pm*, and rhizomania, conditioned by *Rz* and factors from *B.v.* subsp. *maritima*. CP08 segregates for hypocotyl color and is likely self-sterile (S^sS^s) although segregation for self-fertility (S^f) is possible. As a line it shows intermediate nonbolting tendency. At Brawley, CA, under rhizomania conditions, it has higher sugar yield and sucrose concentration than lines with similar germplasm and parentage. At Brawley, the late season survival score is superior to most other entries. Under moderate to severe rhizomania and unknown soil-borne problems at Brawley, the canopy of CP08 remains dark green. This appears to be due to a combination of high resistance to rhizomania and/or other soil borne factors, high resistance to powdery mildew, and resistance to phytotoxemia from the feeding of *Empoasca*, the western potato leaf hopper. CP08 was increased from one full-sib line that in progeny tests in 2000 at Brawley and Salinas, segregated for high resistance to powdery mildew, resistance to rhizomania, and under severe rhizomania, segregated for very good appearance and survival scores under high temperatures. This full-sib progeny resulted from backcrosses to transfer and combine *Pm* and *Rz*. A number of powdery mildew resistant plants from CP02 were backcrossed to plants of C78/3, the source of *Rz*. Individual plans from this series of backcrosses that appeared by paired crosses in the greenhouse under paper bags to plants from C37. Backcross P918-6 was selected from progeny tests in 2000 and increased to produce line P118-6. Seed of P118-6 was released as CP08. About 2% of CP08 was derived from WB242, 25% from C78/3, and 73% from C37. Under severe rhizomania and high temperature conditions, CP08 is strikingly different from C78/3 and C37 for resistance to rhizomania, powdery mildew, and the feeding effects of *Empoasca*. Under these conditions at Brawley, CP08 has a very desirable, dark green appearance that gives the canopy a "stay-green" tendency.

Lines CP07 and CP08 should be evaluated as sources from which to develop potential pollinators for high performing, disease and bolting resistant hybrids. These lines may be useful as a

combined source of high resistance to powdery mildew and rhizomania. They need to be evaluated further as a potential source of tolerance to cyst nematode and *Empoasca* leaf hoppers.

Seed of CP07 and CP08 will be maintained at the USDA, ARS, U.S. Agricultural Research Station, Salinas, California, and will be provided upon written request to sugarbeet breeders in sufficient quantities for reproduction. Genetic material of these releases has been deposited in the National Plant Germplasm System where it will be available for research purposes, including development and commercialization of new parental lines and cultivars. It is requested that appropriate recognition be made if this germplasm contributes to the development of a new breeding line or cultivar. The National Germplasm System and additional information on prior releases and PI numbers can be found at: www.ars-grin.gov.

INDEX OF VARIETY TRIALS, SALINAS, CA, 2002
U.S. AGRICULTURAL RESEARCH STATION

Tests were located in three field plot areas at Salinas and two at Brawley, CA. Disease nurseries were also used in Idaho, Colorado, and Minnesota. Tests at Brawley (Imperial Valley) were planted in September 2001, and harvested from May through June, 2002. Tests at Salinas were planted from November, 2001 through August, 2002, and harvested from September through December. Tests at Spence Field (Salinas) were under both rhizomania and nonrhizomania (following methyl bromide fumigation) conditions. Herbicides were not used in Block 6 trials that followed strawberries and methyl bromide fumigation. Nortron, Pyramin, Betamix, Progress, and Poast were used in the other trials. Bayleton at 2lbs material/acre was used for powdery mildew control. Lorsban-4E was applied for aphid and other insect control. The specific planting and harvest dates as well as plot size and design are shown on each test summary.

Tests are listed in the main Table of Contents for Salinas by types of material and evaluation. As an aid to find test summaries, they are listed below by ascending test (planting date) number and cross- referenced to the page number. Tests shown as N/A are not available or not included in this report.

Test results shown as C are combined and summarized across tests.

TEST 2502. PERFORMANCE OF LINES, SALINAS, CA, 2002

48 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: February 27, 2002
Harvested: October 10, 2002

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Powdery Mildew Score	Virus Yellows Mean	Bolting %
2502-1:	Multigerm, O.P. lines, 16V x 8R, RCB(e)								
Y190H5	0833-5HO x RZM Y090	16108	46.21	17.40	99	84.0	4.5	1.8	0.0
Phoenix	rec'd 8-16-01	19548	59.05	16.55	160	86.8	5.9	3.0	0.0
Crystal 205	2-22-02 (Lot 0205C8602)	17545	48.67	18.02	155	85.2	5.0	3.9	0.4
01-US75	Inc. 00-US75, (US75)	13770	45.10	15.25	151	80.4	7.5	2.6	0.4
01-C37	Inc. U86-37, (C37)	16471	48.96	16.83	151	83.9	7.9	1.8	0.0
99-C31/6	Inc. F86-31/6, (C31/6)	15665	49.33	15.89	153	82.5	4.4	1.9	0.0
R176-89	RZM R076-89	16066	49.58	16.17	147	85.1	3.4	1.8	0.0
R176-89-18	RZM R076-89-18, (C76-89-18)	17942	54.39	16.50	156	84.2	5.1	1.6	0.0
R176-89-5	RZM R076-89-5, (C76-89-5)	16066	47.41	16.92	153	83.6	2.4	2.2	0.0
99-C46/2	Inc. U86-46/2, (C46/2)	15647	47.64	16.39	153	83.7	5.0	2.1	0.0
R178	RZM-ER-% R978, (C78/2)	15472	46.46	16.64	155	82.4	3.3	2.0	0.4
Y169	RZM-ER-% Y969, (C69)	18064	52.55	17.19	155	83.1	3.5	2.2	0.0
Y190	RZMY090	17423	50.95	17.09	135	84.4	5.0	1.7	0.0
Y191	Inc. FS(C),C1,Syn 1 FS sel.	17482	51.19	17.08	153	83.8	4.3	1.9	0.4
R180	RZM-ER-% R980, (C80/2)	17873	52.05	17.16	148	84.6	5.4	1.9	0.0
R170	RZM-ER-% R970	16755	49.98	16.73	151	84.1	5.1	2.2	0.0
Mean		16743.7	49.97	16.74	148.4	83.9	4.8	2.2	0.1
LSD (.05)		1295.5	3.22	0.66	8.4	2.2	0.8	0.4	0.5
C.V. (%)		7.9	6.51	3.97	5.7	2.7	15.7	18.0	538.0
F value		8.7**	9.12**	7.54**	22.5**	3.1**	28.6**	18.0**	0.9NS

TEST 2502. PERFORMANCE OF LINES, SALINAS, CA, 2002
48 entries x 8 reps., RCB(e). ANOVA across tests to compare means.

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Powdery Mildew Score	Virus Yellows Mean	Bolting %
Mean		16560.7	49.86	16.60	147.4	83.9	4.6	2.2	0.3
LSD (.05)		1435.3	3.62	0.70	12.4	2.3	0.8	0.5	1.6
C.V. (%)		8.8	7.36	4.29	8.5	2.8	17.6	21.1	482.4
F value		6.2**	7.07**	7.60**	4.4**	2.2**	20.9**	15.0**	2.3**

TEST 2502. PERFORMANCE OF LINES, SALINAS, CA, 2002

(cont.)

Variety	Description	Acre Yield			Beets/100' No.	RJAP %	Powdery Mildew Score	Virus Yellows Mean	Bolting %
		Sugar Lbs	Beets Tons	Sucrose %					
2502-2: Multigerm lines with Bvm, 16V x 8R, RCB(e)									
Beta 6600	rec'd 7-11-00 (%S check)	16830	43.50	19.38	155	86.6	5.3	2.9	0.4
Beta 4776R	rec'd 8-31-01	18979	53.21	17.83	155	86.0	2.4	2.9	0.0
R021	RZM R926,R927, (C26,C27)	15444	47.51	16.24	145	84.0	5.6	2.1	1.1
R039	Inc. R539, (C39R)	17191	52.82	16.30	141	84.4	2.9	2.3	0.0
01-EL0204	RZM 00-EL0204, (EL0204)	17458	55.78	15.64	156	84.6	5.4	2.5	0.0
01-SP22-O	Inc. 00-SP22-O, (SP22-O)	13737	42.12	16.27	147	85.4	4.4	4.8	0.0
Y167	RZM-ER-% Y967, (C67/2)	17021	50.44	16.88	149	84.0	4.3	2.1	0.0
Y171	RZM-ER-% Y971	17014	50.59	16.80	148	85.2	6.5	1.7	1.1
Y175	RZM Y075	15418	46.76	16.38	144	84.6	5.3	2.0	0.0
R143	RZM-ER-% R943	14625	45.10	16.17	148	83.8	4.1	2.8	0.0
R140	RZM-ER-% R940,R954	15859	48.62	16.30	155	84.6	5.0	2.1	0.0
P127	PMR-P027-#(C),P027B-#(C)	15483	46.86	16.51	152	82.3	7.6	1.8	2.4
P128	PMR P028-#(C)	17761	53.11	16.73	148	83.3	4.5	1.7	0.0
P129	PMR-RZM P029-#(C)	16855	50.80	16.56	145	83.7	3.1	2.1	0.0
P130	PMR-RZM P030-#(C)	14977	46.36	16.13	149	82.7	3.1	2.1	0.4
P007/8	PMR-RZM P807,P808	16022	47.62	16.83	156	84.0	2.4	2.0	1.2
Mean		16292.1	48.82	16.68	149.5	84.3	4.5	2.4	0.4
LSD (.05)		1479.1	3.82	0.68	7.8	2.0	0.8	0.5	2.2
C.V. (%)		9.2	7.89	4.11	5.3	2.4	17.8	23.0	531.9
F value		6.4**	7.76**	12.60**	2.7**	2.5*	27.4**	15.3**	0.8NS

A42

TEST 2502. PERFORMANCE OF LINES, SALINAS, CA, 2002
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Powdery Mildew Score	Virus Yellows Mean	Bolting %
2502-3:	Multigerm,S^f,Aa populations, 16V x 8R, RCB(e)								
0747	Inc.7747(A,aa), (popn-747)	16427	51.16	16.00	143	83.6	6.4	1.5	0.0
1931	RZM 0931aa x A, (popn-931)	16787	52.60	15.96	136	83.3	4.6	1.7	0.0
1941	RZM 0941aa x A, (popn-941)	17430	52.65	16.54	141	83.2	4.0	1.8	0.0
Z125	RZM Z025aa x A, (popn-Z25)	16783	48.72	17.24	140	83.5	4.6	3.3	0.7
CR111	CR011aa x A	16437	50.91	16.10	146	81.4	5.1	2.3	5.4
1942	RZM 0942aa x A, (popn-942)	16668	51.34	16.21	144	81.8	2.5	2.0	0.0
01-FC1030	RZM 19991030,…aa x A	15568	46.05	16.80	144	85.1	5.3	2.6	1.5
1933	RZM-ER-% 9933 (A,aa)	17049	49.98	17.06	147	84.4	4.4	1.7	0.0
1932	RZM-ER-% 9932 (A,aa)	16552	50.39	16.42	147	84.0	5.0	2.3	0.0
1924	RZM-ER-% 9924 (A,aa)	16589	50.47	16.40	147	83.4	4.4	2.2	0.0
N124	NR-RZM N024(galls) (A,aa)	14919	47.36	15.73	152	83.8	3.6	1.8	0.0
N112	NR-RZM P912 (A,aa)	16389	50.04	16.35	153	83.3	3.1	1.6	0.0
N172	NR-RZM N972 (A,aa)	13940	45.55	15.26	145	83.5	3.4	2.1	0.4
Y190H41	0941aa x RZM Y090	18358	55.73	16.49	134	84.2	4.4	1.8	0.0
Y190H25	Z025aa x RZM Y090	18394	53.74	17.09	136	84.0	5.0	2.4	0.0
Beta 4430R	rec'd 8-31-01	18052	55.69	16.21	153	85.3	3.9	3.7	0.3
Mean		16646.3	50.78	16.37	144.3	83.6	4.4	2.2	0.5
LSD (.05)		1517.8	3.78	0.79	10.2	2.6	0.7	0.5	1.8
C.V. (%)		9.3	7.51	4.89	7.1	3.1	16.8	20.8	346.1
F value		4.6**	4.83**	3.36**	2.5**	1.2NS	13.2**	14.2**	4.5**

Notes: See Test 2102 for VY (BChV) inoculated and relative VY %loss.

Virus yellows was scored 6/26, 7/18, 8/05, & 8/29 on a scale of 0 to 9, where 9 = 90-100% of mature leaves showing yellowing symptoms. Plots were not inoculated so this VY reflects natural infection with BChV and BWYV. Natural infection was late and mild.

Powdery mildew was controlled until the end of season. PM should have had relatively little effect on yield.

A43

TEST 2802.   PERFORMANCE OF PROGENY LINES SELECTED FOR VIRUS YELLOWS RESISTANCE WITHOUT BChV, SALINAS, CA, 2002

12 entries x 8 reps., RCB
1-row plots, 22 ft. long

Planted: February 27, 2002
Harvested: October 8, 2002

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Powdery Mildew Score	Virus Yellows 8/29	Virus Yellows Mean	Bolting %
Checks										
01-SP22-O	Inc. 00-SP22-O, (SP22-O)	14726	45.75	16.05	148	83.0	4.3	6.4	4.9	0.4
R176-89	RZM R076-89	17263	51.09	16.88	143	85.6	4.1	2.9	1.5	0.0
Progeny lines increased in 2000										
0930-19	8930-19aa x A, (C930-19)	19204	55.98	17.15	148	86.7	1.4	1.3	0.8	0.0
Z025-9	Z825-9aa x A, (CZ25-9)	15020	40.33	18.63	153	81.8	1.4	7.0	4.2	0.0
0929-112	8929-112aa x A	15836	46.96	16.83	149	82.6	3.8	3.8	1.9	0.4
CR009-1	RZM CR909-1aa x A, (CR09-1)	16201	45.73	17.71	144	81.9	4.9	2.1	1.2	0.0
Progeny lines increased in 2001										
1927-4	RZM 9927-4aa x A, (C927-4)	17730	53.21	16.66	143	84.9	5.9	2.5	1.4	0.0
1929-62	RZM 9929-62aa x A, (C929-62)	14867	46.72	15.81	144	83.7	2.0	3.1	2.0	0.4
1930-35A	RZM 9930-35A, (C930-35)	12922	35.78	18.02	137	84.3	4.0	5.5	3.9	2.5
1929-4	RZM 9929-4aa x A	17526	48.42	18.11	139	83.9	1.6	3.8	1.9	0.0
1924-2	RZM 9924-2aa x A	14398	39.87	18.02	118	85.4	0.9	2.5	1.4	0.0
R176-89-5-4	Inc. R976-89-5-4	18373	52.35	17.56	152	83.7	2.8	2.5	1.4	0.0
Mean		16172.2	46.85	17.29	143.1	84.0	3.1	3.6	2.2	0.3
LSD (.05)		1457.2	3.12	0.92	11.3	2.8	0.9	0.7	0.4	1.2
C.V. (%)		9.1	6.69	5.33	8.0	3.3	29.3	18.3	20.0	389.9
F value		13.1**	28.92**	7.12**	5.5**	2.3*	25.9**	58.4**	72.3**	2.8**

Notes: See Test 2402 for VY (BChV) inoculated and relative VY %loss.

Virus yellows was scored 6/26, 7/18, 8/05, & 8/29 on a scale of 0 to 9, where 9 = 90-100% of mature leaves showing yellowing symptoms.   Plots were not inoculated so this VY reflects natural infection with BChV and BWYV.   Natural infection was late and mild.

Powdery mildew was controled until the end of season.   PM should have had relatively little effect on yield.

TEST 3502. EVALUATION OF SELECTED MULTIGERM PROGENY LINES, SALINAS, CA, 2002

Planted: February 28, 2002
Harvested: September 26, 2002

48 entries x 4 reps., RCB
1-row plots, 11 ft. long

| Variety | Description | Acre Yield | | Sucrose | Beets/100' | RJAP | Powdery Mildew |
		Sugar Lbs	Beets Tons	%	No.	%	9/23
Checks							
01-SP22-O	Inc. 00-SP22-0	14036	43.74	15.98	150	84.3	3.3
0930-19	8930-19aa x A	16811	49.78	16.88	155	86.1	1.5
Inc. S₁ progeny lines							
1930-35A	RZM 9930-35A, (C930-35)	12037	34.26	17.63	141	86.0	2.5
1929-62	RZM 9929-62aa x A, (C929-62)	14061	44.95	15.60	145	81.5	0.8
1927-4	RZM 9927-4aa x A, (C927-4)	17811	55.24	16.15	148	85.6	4.0
1929-4	RZM 9929-4aa x A	17010	48.53	17.52	148	83.4	1.3
1924-2	RZM 9924-2aa x A	12661	35.97	17.52	125	87.0	0.3
1930-19	NB 8930-19 (A,aa), (C930-19)	15361	47.97	15.97	164	85.7	0.5
Z025-9	Z825-9aa x A, (CZ25-9)	14899	39.71	18.75	159	84.4	1.3
0929-112	8929-112aa x A	14459	42.33	17.00	159	85.3	3.0
Z131-20	Inc. Z931-20 (A,aa)	13597	38.29	17.75	139	84.9	1.8
CR009-1	CR009-1aa x A, (CR09-1)	15213	44.95	16.95	157	84.1	4.0
CR110-14-2	Inc. CR910-14-2 (A,aa)	11326	34.47	16.40	155	84.0	3.3
CR110-5	Inc. CR910-5 (A,aa)	13050	39.30	16.65	159	86.1	2.8
CR112-5	Inc. CR812-5 (A,aa)	12884	40.31	15.95	157	84.7	5.3
Z131-14	Inc. Z931-14 (A,aa)	11845	39.30	15.13	150	83.3	3.0
Z131-18	Inc. Z931-18 (A,aa)	15364	42.33	18.15	166	84.9	1.8
1935-6	Inc. 9935-6 (A,aa)	11524	34.06	16.88	168	83.6	0.8
1936-14	Inc. 9936-14 (A,aa)	15255	45.35	16.75	145	84.9	1.8
1931-56	Inc. 9931-56 (A,aa)	13098	39.91	16.48	155	84.6	1.3
1931-201	Inc. 9931-201 (A,aa)	14730	44.34	16.58	157	83.8	1.0

A45

TEST 3502. EVALUATION OF SELECTED MULTIGERM PROGENY LINES, SALINAS, CA, 2002
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Powdery Mildew 9/23
Increase FS progeny lines							
R178-5	Inc. R978-5	15510	44.95	17.25	155	88.0	2.8
R178-6	Inc. R978-6	14759	43.74	16.88	159	86.3	3.5
R178-11	Inc. R978-11	17252	53.61	15.98	157	83.7	3.0
R180-11	Inc. R980-11	17973	51.80	17.38	164	85.1	5.3
R180-16	Inc. R980-16	17934	50.99	17.63	159	86.4	5.8
R180-21	Inc. R980-21	19031	53.91	17.65	148	85.2	4.0
Y168-8	Inc. Y968-8	14734	44.14	16.70	157	85.5	3.5
Y168-13	Inc. Y968-13	16126	46.15	17.52	157	83.7	1.5
Y168-16	Inc. Y968-16	16703	46.07	18.10	157	84.7	2.3
Y167-5	Inc. Y967-5	17365	49.98	17.38	168	85.4	2.8
Y172-1	Inc. Y972-1	16613	47.16	17.63	164	84.5	5.0
Y172-5	Inc. Y972-5	16899	50.19	16.85	166	82.6	4.5
Y172-7	Inc. Y972-7	13724	42.33	16.27	166	86.2	5.0
Y175-13	Inc. Y975-13	14215	42.12	16.88	161	84.2	3.5
R181-22	Inc. R981-22	18262	51.60	17.73	157	85.9	3.0
R176-89-5	RZM R076-89-5	15780	45.75	17.30	159	86.9	3.0
R176-89-5-4	Inc. R976-89-5-4	16979	47.77	17.75	155	86.1	1.3
R176-89-5NB-4	Inc. R976-89-5NB-4	15337	43.94	17.42	157	86.1	1.5
R176-89-5-13	Inc. R976-89-5-13	15841	44.14	17.88	161	86.4	3.8
Sources of progeny lines							
1931	RZM 0931aa x A	20293	59.66	17.02	157	86.0	4.0
1941	RZM 0941aa x A	17992	54.02	16.67	145	86.2	4.0
R178	RZM-ER-% R978, (C78/3)	17092	50.19	17.05	152	85.6	4.5
Y190	Inc. Y090	19827	55.93	17.67	134	85.5	5.0
P118-6	Inc. P918-6	17944	53.81	16.65	159	86.6	3.8
P125-12	Inc. P925-12	14905	43.94	16.92	157	86.7	3.3

TEST 3502. EVALUATION OF SELECTED MULTIGERM PROGENY LINES, SALINAS, CA, 2002

(cont.)

| Variety | Description | Acre Yield | | Sucrose | Beets/ 100' | RJAP | Powdery Mildew |
		Sugar Lbs	Beets Tons	%	No.	%	9/23
Commercial checks							
Phoenix	rec'd 8-16-01	18291	55.43	16.42	166	89.7	5.3
Beta 4430R	rec'd 8-31-01	20020	59.05	16.98	161	87.5	4.3
Mean		15717.4	46.20	17.00	155.3	85.3	3.0
LSD (.05)		3001.0	8.41	1.01	16.8	3.1	1.5
C.V. (%)		13.7	13.03	4.24	7.7	2.6	35.2
F value		4.4**	4.47**	3.97**	2.1**	1.7*	7.7**

Notes: Also see Tests 302, 402, 2402, 2802, 5502, 7102 and others. Full-sib and S_1 progeny tests were run at Salinas and Brawley. On the basis of these tests under various conditions, individual FS or S_1 families were selected, increased, and crossed to a monogerm, male-sterile tester for further evaluations. In these tests, the progeny lines were evaluated per se.

A47

TEST 2102. PERFORMANCE OF LINES UNDER BChV INFECTION, SALINAS, CA, 2002

24 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: February 27, 2002
Harvested: October 15, 2002
Inoc. BChV: May 9, 2002

Variety	Description	Acre Yield				Beets/100' No.	RJAP %	Virus Yellows Scores				
		Sugar Lbs	Loss[1] %	Beets Tons	Sucrose %			6/26	7/18	8/05	8/29	Mean
Checks												
01-SP22-0	Inc. 00-SP22-0, (SP22-O)	8825	35.76	30.01	14.26	148	82.8	6.3	7.3	6.9	7.3	6.9
01-US75	Inc. 00-US75, (US75)	9924	27.93	37.69	13.15	160	82.4	4.1	5.0	5.1	6.4	5.2
01-C37	Inc. U86-37, (C37)	15387	6.58	47.84	16.08	156	84.4	1.0	2.8	2.9	4.1	2.7
99-C31/6	Inc. F86-31/6, (C31/6)	14503	7.42	46.98	15.39	153	84.2	1.4	3.3	2.9	4.0	2.9
VYR O.P. lines												
Y169	RZM-ER-% Y969	16959	6.11	49.88	17.00	159	83.5	2.0	4.1	3.6	4.3	3.5
R176-89	RZM R076-89	12152	24.36	39.45	15.39	168	83.2	2.6	3.0	2.9	3.5	3.0
R176-89-18	RZM R076-89-18, (C76-89-18)	15515	13.53	50.14	15.44	159	84.1	1.8	3.3	3.3	4.1	3.1
R176-89-5	RZM R076-89-5, (C76-89-5)	15974	0.57	48.98	16.30	157	84.4	1.6	3.0	3.1	3.9	2.9
99-C46/2	Inc. U86-46/2, (C46/2)	14459	7.60	43.64	16.51	147	84.3	2.8	3.9	3.8	4.6	3.8
R178	RZM-ER-% R978, (C78/2)	14145	8.58	43.74	16.06	161	83.2	2.9	4.3	3.9	4.3	3.8
R180	RZM-ER-% R980, (C80/2)	16075	10.06	49.74	16.13	156	83.2	2.9	3.9	3.5	4.6	3.7
Y190	RZM Y090	15642	10.22	46.68	16.73	131	84.1	1.9	3.6	3.4	4.4	3.3
VYR O.P. lines with *Bvm*												
Y167	RZM-ER-% Y967, (C67/2)	16073	5.57	48.56	16.54	149	84.5	2.9	3.8	3.5	4.8	3.7
Y171	RZM-ER-% Y971	15782	7.24	47.87	16.46	152	84.3	1.6	3.1	3.1	4.4	3.1
Y175	RZM Y075	13997	9.22	45.50	15.32	148	83.6	2.5	4.3	3.6	4.4	3.7
R021	RZM R926,R927,(C26,C27)	15183	1.69	46.96	16.16	149	83.6	1.9	3.6	2.9	4.0	3.1
MM,S[f] Aa populations												
1931	RZM 0931aa x A, (popn-931)	15907	5.24	49.33	16.11	138	83.3	1.6	3.5	3.1	4.3	3.1
1941	RZM 0941aa x A, (popn-941)	17022	2.34	51.45	16.51	153	84.5	1.6	3.1	3.3	4.8	3.2
1942	RZM 0942aa x A, (popn-942)	14661	12.04	45.70	16.05	146	81.7	2.3	3.8	4.0	4.9	3.7
Z125	RZM Z025aa x A, (popn-Z25)	14386	14.28	42.98	16.76	148	83.4	3.3	5.0	4.9	5.8	4.7

(cont.)

Variety	Description	Acre Yield Sugar Loss[1] Lbs	%	Beets Tons	Beets Sucrose %	Beets/100' No.	RJAP %	Virus Yellows Scores 6/26	7/18	8/05	8/29	Mean
Commercial hybrid checks												
Phoenix	rec'd 8-16-01	14781	24.39	46.56	15.85	159	85.9	5.1	5.4	5.5	6.3	5.6
Beta 4776R	rec'd 8-31-01	15804	16.73	47.11	16.75	149	86.0	4.8	5.4	5.9	6.6	5.7
Y190H5	0833-5HO x RZM Y090	16553	-2.77	47.45	17.45	127	84.1	2.0	3.6	3.9	4.9	3.6
Crystal 205	rec'd 2-22-02 (0205C8602)	12216	30.37	38.09	16.02	153	83.4	5.4	6.1	6.3	7.5	6.3
Mean		14663.6		45.51	16.02	151.1	83.8	2.8	4.1	4.0	4.9	3.9
LSD (.05)		1459.1		3.53	0.89	11.7	2.4	0.7	0.7	0.6	0.6	0.4
C.V. (%)		10.1		7.88	5.65	7.9	2.9	23.5	16.01	16.5	12.1	11.4
F value		15.3**		15.14**	7.92**	4.8**	1.3NS	37.4**	22.6**	25.3**	27.7**	54.3**

[1]Test 2102 and Test 2502 are companion tests. Test 2102 was inoculated May 9, 2002 with *Beet chlorosis virus* (BChV). % loss is the relative sugar yield loss calculated from the corresponding means in each test.

Notes: Virus yellows foliar symptoms were scored on a scale of 0 to 9, where 9 = 90-100% of the mature leaf area yellowed. Scores were made on 6/26, 7/18, 8/05, and 8/29 by JAO.

Test 2102 thru 2802 were grown on soil that had been fumigated with methyl bromide in 2000 prior to strawberries in 2001. There appeared to be minimal soil borne problems including no observed rhizomania or sugarbeet cyst nematode. Foliar diseases of rust and downy mildew were minor to moderate. Aphids and worms were controlled as needed with Lorsban and herbicide treatment of Nortron/Betamix was applied once following thinning.

Coefficients of Correlation: Partial sets of coefficients of correlation (r), n = 24 were run within the VY inoculated test. These comparisons were chosen to determine the relationship or association between measures of VY (VY scores for individual dates and for the mean VY score) and performance factors and between VY scores and relative % sugar yield loss. There were fair to good associations between VY score and sugar yield but there were good correlations between VY score and relative % sugar yield loss. These results suggest that scoring entries for VY (*Beet Chlorosis Virus*) is predictive of their reaction to VY.

A49

(cont.)

Variety	Description	Acre Yield				Beets/100' RJAP		Virus Yellows Scores				
		Sugar Lbs	Loss[1] %	Beets Tons	Sucrose %	No.	%	6/26 %	7/18	8/05	8/29	Mean

Correlations within VY inoculated test 2102

	SY	RY	%S	RJAP	%loss
VY mean	-.63**	-.70**	-.34NS	-.01NS	.81**
VY 8/29	-.54**	-.61**	-.29NS	-.02NS	.74**
VY 8/05	-.59**				.78**
VY 7/18	-.64**				.77**
VY 6/26	-.66**				.84**
% sugar	.82**				

Correlations between corresponding test
Non-inoculated test (Test 2502)

VY Inoc.	SY	%S	VY mean	VY 8/29	VY 7/18
SY	.63**				
%S		.70**			
VY mean			.92**		
VY 8/29				.92**	
VY 7/18					.89**

Correlations were also run between the entry means for corresponding VY inoculated and noninoculated tests. There were good associations between these tests for sugar yield and %S, but high correlations between VY scores on the same dates. This suggests that the milder and later natural VY (BChV/BWYV) infection in the non-inoculated test could also be used to predict VY reaction of these entries.

TEST 2402. PERFORMANCE OF PROGENY LINES SELECTED FOR VIRUS YELLOWS RESISTANCE UNDER BChV, SALINAS, CA, 2002

Planted: February 27, 2002
Harvested: October 16, 2002

12 entries x 8 reps., RCB
1-row plots, 22 ft. long

| Variety | Description | Acre Yield | | | | Beets/100' | RJAP | Powdery Mildew | Virus Yellows | | | |
		Sugar lbs	Loss[1] %	Beets Tons	Sucrose %	No.	%	Score	6/26	8/5	8/29	Mean
Checks												
01-SP22-O	Inc. 00-SP22-O, (SP22-O)	9821	33.31	33.93	14.44	160	83.6	5.6	5.6	6.5	7.1	6.6
R176-89	RZM R076-89	14789	14.33	47.35	15.63	147	83.7	2.6	1.3	2.5	3.9	2.6
Progeny lines increased in 2000												
0930-19	8930-19aa x A,(C930-19)	16084	16.25	50.95	15.79	155	85.1	1.1	1.9	2.0	3.0	2.3
Z025-9	Z825-9aa x A,(CZ25-9)	9909	34.03	29.62	16.69	159	82.1	1.1	4.6	7.3	7.8	6.5
0929-112	8929-112aa x A	13124	17.13	40.66	16.09	145	82.5	2.9	1.0	4.1	5.8	3.6
CR009-1	RZM CR909-1aa x A,(CR09-1)	14309	11.67	43.55	16.43	151	81.6	5.3	1.3	2.4	3.8	2.5
Progeny lines increased in 2001												
1927-4	RZM 9927-4aa x A,(C927-4)	16550	6.65	52.37	15.80	142	84.9	6.8	1.1	2.4	3.8	2.5
1929-62	RZM 9929-62aa x A,(C929-62)	12051	18.94	40.90	14.73	157	82.6	1.3	2.4	3.0	4.4	3.3
1930-35A	RZM 9930-35A,(C930-35)	9372	27.47	27.95	16.75	142	83.1	3.6	4.6	5.0	6.6	5.5
1929-4	RZM 9929-4aa x A	14493	17.31	43.73	16.56	141	83.3	1.8	4.3	4.8	5.9	4.9
1924-2	RZM 9924-2aa x A	12738	11.53	37.93	16.76	113	83.9	1.0	1.1	2.1	3.1	2.4
R176-89-5-4	Inc. R976-89-5-4	17856	2.82	52.06	17.13	160	84.5	1.6	1.3	2.0	3.1	2.1
Mean		13424.7		41.75	16.07	147.6	83.4	2.9	2.5	3.7	4.8	3.7
LSD (.05)		1368.5		3.15	0.92	15.9	2.2	0.8	0.6	0.5	0.6	0.3
C.V. (%)		10.2		7.57	5.77	10.8	2.7	28.0	21.7	14.5	13.3	9.1
F value		32.5**		55.08**	6.47**	5.4**	1.9NS	49.1**	79.2**	95.2**	55.7**	195.1**

[1]Test 2402 and Test 2802 are companion tests. Test 2402 was inoculated May 9, 2002 with *Beet chlorosis virus* (BChV). % loss is the relative sugar yield loss calculated from the corresponding means in each test.

Notes: Virus yellows foliar symptoms were scored on a scale of 0 to 9, where 9 = 90-100% of the mature leaf area yellowed. Scores were made on 6/26, 7/18, 8/05, and 8/29 by JAO.

TEST 2402.   PERFORMANCE OF PROGENY LINES SELECTED FOR VIRUS YELLOWS RESISTANCE UNDER BChV, SALINAS, CA, 2002

(cont.)

		Acre Yield			Beets/		Powdery Mildew		Virus Yellows			
		Sugar	Loss[1]	Beets	Sucrose	100'	RJAP	Score	6/26	8/5	8/29	Mean
Variety	Description	Lbs	%	Tons	%	No.	%					

Notes (cont.):   Powdery mildew was scored on a scale of 0 to 9, where 9 = 90-100% of mature leaf area covered with mildew.   PM was controlled until late in the season so PM should have had relatively little effect.

Test 2102 thru 2802 were grown on soil that had been fumigated with methyl bromide in 2000 prior to strawberries in 2001.   There appeared to be minimal soil borne problems including no observed rhizomania or sugarbeet cyst nematode.   Foliar diseases of rust and downy mildew were minor to moderate.   Aphids and worms were controlled as needed with Lorsban and herbicide treatment of Nortron/Betamix was applied once following thinning.

Coefficients of Correlation: Partial sets of coefficients of correlation (r), n = 12 were run within the VY inoculated test.   These comparisons were chosen to determine the relationship or association between measures of VY (VY scores for individual dates and for the mean VY score) and performance factors and between VY scores and relative % sugar yield loss.   There were fair to good associations between VY score and sugar yield but there were good correlations between VY score and relative % sugar yield loss.   These results suggest that scoring entries for VY (Beet Chlorosis Virus) is predictive of their reaction to VY.

Correlations within VY inoculated test 2402

	SY	RY	%S	RJAP	%loss
VY mean	-.67*	-.61*	.04NS	-.47NS	.92**
VY 8/29	-.64**	-.63*	.17NS	-.56NS	.88**
VY 8/05	-.67*				.90**
VY 7/18	-.67*				.92**
VY 6/26	-.58*				.86**
% sugar	-.08NS				

Correlations between corresponding test (Test 2802)

| | Non-inoculated test (Test 2802) | | | | |
VY Inoc.	SY	%S	VY mean	VY 8/29	VY 7/18
SY	.90**				
%S		.89**			
VY mean			.94**		
VY 8/29				.96**	
VY 7/18					.94**

Correlations were also run between the entry means for corresponding VY inoculated and noninoculated tests.   There was a good association between these tests for sugar yield and %S, and high correlations between VY scores on the same dates.   This suggests that the milder and later natural VY (BChV/BWYV) infection in the non-inoculated test could also be used to predict VY reaction of these entries.

A52

TEST 7302. PERFORMANCE OF LINES UNDER RHIZOMANIA, SALINAS, CA, 2002

48 entries x 8 reps., RCB(e); 3 subtests, 16x8,RCB(e)
1-row plots, 22 ft. long

Planted: April 19, 2002
Harvested: October 24, 2002

Variety	Description	Source Resist	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Root Rot %	Powdery Mildew 10/23
7302-1: Multigerm, O.P. Lines, 16V x 8R, RCB(e)									
Y190H5	0833-5HO x RZM Y090	Rz	12318	33.96	18.13	111	86.1	9.1	5.1
Phoenix	rec'd 8-16-01	Rz	10475	29.87	17.51	155	88.1	15.2	6.5
Beta 4776R	rec'd 2-5-02	Rz	12469	35.54	17.55	170	87.0	6.0	3.1
01-US75	Inc. 00-US75, (US75)	rzrz	7465	24.30	15.40	164	82.5	4.6	8.6
01-C37	Inc. U86-37, (C37)	rzrz	8485	25.22	16.88	165	86.3	11.6	8.3
99-C31/6	Inc. F86-31/6, (C31/6)	rzrz	8376	26.32	15.93	160	84.9	8.0	5.3
R176-89	RZM R076-89	Rz	9761	28.32	17.27	149	85.0	11.8	4.3
R176-89-18	RZM R076-89-18, (C76-89-18)	Q	10795	31.43	17.21	154	86.2	9.3	6.1
R176-89-5	RZM R076-89-5, (C76-89-5)	Rz	9452	26.96	17.60	157	84.9	7.3	3.3
99-C46/2	Inc. U86-46/2, (C46/2)	rzrz	9112	26.18	17.34	162	86.8	9.8	5.4
R178	RZM-ER-% R978, (C78/2)	Rz	10060	28.14	17.91	158	84.9	17.5	5.1
Y169	RZM-ER-% Y969, (C69)	Rz	10262	29.12	17.65	165	84.6	9.9	4.4
Y190	RZM Y090, C2, syn 1 FS sel.	Rz	10954	31.46	17.44	128	84.1	12.8	5.5
Y191	Inc. FS(C),C1,syn 1 FS sel.	Rz,C51	10756	30.98	17.36	160	83.2	5.7	4.5
R180	RZM-ER-% R980, (C80/2)	Rz	10830	31.02	17.49	157	83.9	10.0	4.9
R170	RZM-ER-% R970	Rz	10265	30.35	16.91	153	84.5	12.5	6.0
Mean			10114.8	29.32	17.22	154.3	85.2	10.1	5.4
LSD (.05)			966.5	2.78	0.60	9.8	2.4	10.7	0.7
C.V. (%)			9.7	9.58	3.52	6.4	2.8	107.4	13.3
F value			15.1**	9.80**	10.45**	18.3**	3.0**	0.8NS	35.2**

TEST 7302. PERFORMANCE OF LINES UNDER RHIZOMANIA, SALINAS, CA, 2002
48 entries x 8 reps., RCB(e). ANOVA across tests to compare means.

	Sugar Lbs	Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Root Rot %	Powdery Mildew 10/23
Mean	10212.8	29.99	17.00	156.4	84.7	10.9	5.1
LSD (.05)	995.0	2.77	0.60	11.9	2.3	10.6	0.7
C.V. (%)	9.9	9.37	3.59	7.8	2.7	99.0	14.5
F value	12.3**	9.27**	10.25**	6.1**	3.0**	1.8**	29.2**

A53

TEST 7302. PERFORMANCE OF LINES UNDER RHIZOMANIA, SALINAS, CA, 2002

(cont.)

Variety	Description	Source Resist	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Root Rot %	Powdery Mildew 10/23
7302-2: Multigerm lines with Bvm, 16V x 8R, RCB(e)									
Beta 6600	rec'd 2-5-02	rzrz	10206	28.58	17.84	160	87.6	19.6	6.0
Angelina	rec'd 3-19-02	Rz,WB42	13084	34.94	18.74	171	87.6	5.8	8.3
R021	RZM R926,R927,(C26,C27)	Rz,Bvm	10319	31.11	16.58	159	84.1	8.0	6.0
R136	RZM-ER-% R936(C79-8)	C51	10198	31.56	16.19	165	83.0	8.5	7.6
01-EL0204	RZM 00-EL0204	Rz,SR	10590	32.47	16.34	159	85.3	10.8	5.1
01-SP22-0	Inc. 00-SP22-0,(SP22-0)	rzrz	6355	20.96	15.20	154	85.1	7.3	5.0
Y167	RZM-ER-% Y967,(C67/2)	C51	10678	30.79	17.35	155	83.4	8.8	4.0
Y171	RZM-ER-% Y971	C51	10723	32.36	16.58	164	83.9	8.8	7.3
Y175	RZM Y075	Rz,C51	10963	32.54	16.86	145	84.2	11.9	5.4
R143	RZM-ER-% R943	C51	11246	33.00	17.04	162	83.8	6.4	4.8
R140	RZM-ER-% R940,R954	C51	10556	31.24	16.89	164	83.9	8.6	5.3
P127	PMR-P027-#(C),P027B-#(C)	WB97	7487	23.44	15.94	157	82.6	16.2	7.1
P128	PMR P028-#(C)	WB242	10000	30.72	16.27	157	83.3	20.7	2.8
P129	PMR-RZM P029-#(C)	Rz,WB97	10658	31.00	17.21	158	82.5	13.2	3.8
P130	PMR-RZM P030-#(C)	Rz,WB242	10688	31.83	16.75	151	84.6	9.9	4.3
P007/8	PMR-RZM P807,P808	Rz,WB97/242	10778	31.78	16.95	165	82.9	21.6	2.8
Mean			10283.2	30.52	16.80	159.0	84.2	11.6	5.3
LSD (.05)			886.8	2.41	0.51	10.8	2.0	9.7	0.8
C.V. (%)			8.7	7.99	3.08	6.8	2.4	83.8	14.2
F value			22.4**	16.88***	19.27**	2.7**	4.9**	2.3*	38.3**

TEST 7302. PERFORMANCE OF LINES UNDER RHIZOMANIA, SALINAS, CA, 2002

(cont.)

Variety	Description	Source Resist	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Root Rot %	Powdery Mildew 10/23
7302-3:	Multigerm, S^f,Aa populations, 16V x 8R, RCB(e)								
0747	Inc. 7747 (A,aa)	rzrz	9330	30.14	15.48	151	84.5	17.8	6.1
1931	RZM 0931aa x A, (popn-931)	Rz	11043	33.32	16.59	147	84.0	9.2	4.6
1941	RZM 0941aa x A, (popn-941)	Rz	10825	31.49	17.17	144	85.8	20.7	4.0
Z125	RZM Z025aa x A, (popn-Z25)	Rz	11240	32.03	17.55	156	84.1	6.2	4.9
CR111	CR011aa x A	Rz	9954	29.72	16.77	135	83.7	7.7	5.4
1942	RZM 0942aa x A, (popn-942)	Rz	10819	31.08	17.44	157	83.9	14.5	4.0
01-FC1030	RZM 19991030,...aa x A	Rz	8930	26.25	17.05	159	86.0	6.0	5.5
1933	RZM-ER-% 9933(A,aa)	Rz	9920	29.29	16.95	160	84.5	16.0	4.6
1932	RZM-ER-% 9932(A,aa)	Rz	9687	28.77	16.84	167	85.0	9.8	5.3
1924	RZM-ER-% 9924(A,aa)	Rz	10913	31.34	17.39	159	83.6	22.3	4.3
N124	NR-RZM N024(galls)(A,aa)	Rz,Bp	9157	27.20	16.85	161	85.3	12.7	3.6
N112	NR-RZM P912(A,aa)	Rz,WB242	10381	30.39	17.09	161	84.9	7.2	3.6
N172	NR-RZM N972(A,aa)	Rz,WBNR	9802	29.71	16.50	166	82.8	16.5	3.8
Y039	Inc. R539 (C39R)	Q	9712	28.19	17.21	152	85.1	4.4	3.4
HH141	rec'd 8-16-01	Rz	9674	27.58	17.56	152	86.7	0.4	6.4
Beta 4430R	rec'd 8-31-01	Rz	12462	35.62	17.48	165	86.7	4.5	3.9
Mean			10240.5	30.13	17.00	155.8	84.8	11.0	84.8
LSD (.05)			1011.3	2.74	0.68	11.8	2.5	9.7	2.5
C.V. (%)			10.0	9.17	4.03	7.7	3.0	88.7	3.0
F value			6.5**	5.94**	4.68**	4.1**	1.6NS	3.5**	1.6NS

Footnote: Source of resistance where Rz = Holly, rzrz = susceptible; Q = quantitative or unknown;
C51 = resistance from WB (wild beet) Bvm thru 51,R22, or similar; WB42 = wild beet 42, or possibly C48, or
other Bvm; Bvm = resistance from composite of WB or Bvm from NW Europe; WB97 = resistance to powdery mildew
from WB97; WB242 = resistance to powdery mildew from WB242; Bp = nematode resistance from Beta procumbuns;
WBNR = partial nematode resistance from Bvm; SR = smooth root germplasm from EL.

A55

TEST 7302. PERFORMANCE OF LINES UNDER RHIZOMANIA, SALINAS, CA, 2002

(cont.)

| Variety | Description | Source Resist | Acre Yield | | Sucrose | Beets/ 100' | RJAP | Root Rot | Powdery Mildew |
			Sugar Lbs	Beets Tons	%	No.	%	%	10/23

Notes: Test 7302 was planted into soil known to be infested with BNYVV (rhizomania). However, symptom expression was only moderate and beets grew fairly well without typical bearding and hairy roots on the tap root. Nitrogen became depleted by early September. Beet oak-leaf virus (BOLV) also occurred in a high incidence. Downy mildew was moderate on susceptible entries. Natural virus yellows infection (BWYV/BChV) was evident on susceptible varieties by late summer. Root rot was primarily caused by *Sclerotium rolfsii*. Roots with rot were counted and weighed at harvest but were removed from the sugar samples. Powdery mildew was controlled until late in the season, then scored just prior to harvest on a scale of 0 to 9 where 9 = 90-100% of mature leaf area covered with mildew.

Entries included commercial hybrids Phoenix, Beta 4776R, HH141, and Beta 4430 as resistant checks. Non-California variety Beta 6600 was included as a high %S, susceptible check. Angelina from KWS was included as a resistant check and is reported to have resistance from both Rz and WB42.

A56

TEST 7102. EVALUATION OF SELECTED MULTIGERM PROGENY LINES UNDER RHIZOMANIA, SALINAS, 2002

48 entries x 4 reps., RCB
1-row plots, 11 ft. long

Planted: April 22, 2002
Harvested: November 26, 2002

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Root Rot %	Powdery Mildew Mean
Checks								
Beta 6600	susc. ck., rec'd 2-5-02	13276	34.07	19.50	164	87.9	14.3	5.9
0930-19	8930-19aa x A	13472	37.07	18.17	159	87.1	11.8	3.6
Inc. S₁ progeny lines								
1930-35A	RZM 9930-35A, (C930-35)	10934	29.27	18.67	159	83.8	2.8	3.9
1929-62	RZM 9929-62aa x A, (C929-62)	13874	38.96	17.75	157	86.5	19.2	2.2
1927-4	RZM 9927-4aa x A, (C927-4)	13995	40.57	17.25	150	85.7	13.2	4.8
1929-4	RZM 9929-4aa x A	13668	36.75	18.80	161	83.6	7.8	3.4
1924-2	RZM 9924-2aa x A	11669	30.71	18.88	132	88.8	17.9	3.0
1930-19	NB 8930-19 (A,aa), (C930-19)	12598	36.89	17.15	164	87.6	10.0	3.8
Z025-9	Z825-9aa x A, (CZ25-9)	12952	33.02	19.63	159	85.4	8.8	2.3
0929-112	8929-112aa x A	11829	30.84	19.17	143	85.7	10.7	4.0
Z131-20	Inc. Z931-20 (A,aa)	11200	27.88	19.92	125	88.4	5.8	2.7
CR009-1	CR009-1aa x A, (CR09-1)	12625	34.75	18.20	145	84.7	5.1	5.6
CR110-14-2	Inc. CR910-14-2 (A,aa)	9651	28.44	16.95	145	86.5	1.6	6.1
CR110-5	Inc. CR910-5 (A,aa)	8822	25.14	17.55	152	83.8	2.8	4.4
CR112-5	Inc. CR812-5 (A,aa)	11418	34.67	16.52	164	86.6	22.0	6.3
Z131-14	Inc. Z931-14 (A,aa)	12502	31.85	19.58	161	87.6	6.3	5.1
Z131-18	Inc. Z931-18 (A,aa)	14747	39.71	18.48	168	83.4	8.7	2.8
1935-6	Inc. 9935-6 (A,aa)	10139	27.35	18.55	170	83.4	13.2	1.9
1936-14	Inc. 9936-14 (A,aa)	12358	34.27	18.05	159	85.0	5.9	3.1
1931-56	Inc. 9931-56 (A,aa)	14013	38.50	18.20	168	87.9	8.3	1.5
1931-201	Inc. 9931-201 (A,aa)	12250	35.28	17.33	155	84.2	11.8	1.8

A57

TEST 7102. EVALUATION OF SELECTED MULTIGERM PROGENY LINES UNDER RHIZOMANIA, SALINAS, 2002

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Root Rot %	Powdery Mildew Mean
Increase FS progeny lines								
R178-5	Inc. R978-5	13458	37.09	18.17	173	87.7	9.5	4.3
R178-6	Inc. R978-6	13156	38.90	16.90	166	89.2	9.6	3.9
R178-11	Inc. R978-11	14707	40.31	18.25	164	86.7	4.6	5.3
R180-11	Inc. R980-11	14542	39.51	18.40	157	86.4	5.6	5.6
R180-16	Inc. R980-16	13934	38.70	18.02	159	86.4	11.1	6.8
R180-21	Inc. R980-21	14212	39.71	17.92	168	86.0	3.9	5.3
Y168-8	Inc. Y968-8	13052	36.49	17.88	164	87.7	9.8	4.4
Y168-13	Inc. Y968-13	14216	38.10	18.65	170	85.7	2.8	3.1
Y168-16	Inc. Y968-16	14264	36.49	19.60	166	87.5	2.8	3.3
Y167-5	Inc. Y967-5	16111	42.53	18.95	157	87.1	0.0	3.4
Y172-1	Inc. Y972-1	14972	41.52	18.08	159	83.3	0.0	5.5
Y172-5	Inc. Y972-5	14805	41.71	17.77	159	85.5	3.1	5.7
Y172-7	Inc. Y972-7	15025	41.24	18.27	168	87.2	9.6	5.8
Y175-13	Inc. Y975-13	13464	38.10	17.65	164	86.3	7.6	4.8
R181-22	Inc. R981-22	15843	41.32	19.17	170	86.9	2.8	4.4
R176-89-5	RZM R076-89-5, (C76-89-5)	15283	42.13	18.17	161	85.4	3.3	3.8
R176-89-5-4	Inc. R976-89-5-4	14404	38.60	18.73	155	87.0	5.3	3.4
R176-89-5NB-4	Inc. R976-89-5NB-4	13465	36.69	18.35	164	87.4	2.6	4.2
R176-89-5-13	Inc. R976-89-5-13	12255	30.64	19.95	159	88.9	3.8	3.7
Sources of progeny lines								
1931	RZM 0931aa x A	17828	48.58	18.33	152	89.7	8.9	4.5
1941	RZM 0941aa x A	16934	46.44	18.27	155	86.6	11.8	4.4
R178	RZM-ER-% R978, (C78/3)	14118	37.29	18.92	166	86.7	8.3	5.1
Y190	Inc. Y090	14749	40.17	18.33	134	87.7	8.8	4.9
P118-6	Inc. P918-6	13511	38.56	17.60	159	82.5	11.1	4.8
P125-12	Inc. P925-12	13631	36.76	18.52	143	85.8	12.9	4.8

TEST 7102. EVALUATION OF SELECTED MULTIGERM PROGENY LINES UNDER RHIZOMANIA, SALINAS, 2002

(cont.)

| Variety | Description | Acre Yield | | Sucrose | Beets/100' | RJAP | Root Rot | Powdery Mildew |
		Sugar Lbs	Beets Tons	%	No.	%	%	Mean
Commercial checks								
Angelina	resist ck., rec'd 3-19-02	18144	47.47	19.08	161	88.7	14.7	7.2
Beta 4001R	resist ck., rec'd 9-25-01	18680	50.60	18.48	168	89.0	12.5	2.6
Mean		13682.4	37.33	18.35	158.4	86.4	8.2	4.2
LSD (.05)		2120.0	5.87	0.83	20.2	3.0	18.1	0.9
C.V. (%)		11.5	11.24	3.25	9.1	2.5	157.0	4.2
F value		6.5**	6.59**	6.92**	2.0**	2.7**	0.6NS	15.7**

Notes: FS progenies were extracted from MM,O.P.,Rz lines and S_1 progenies were extracted from MM,S^f,Aa,Rz random-mated populations and evaluated as progenies per se for nonbolting, rhizomania resistance, and performance. On the basis of these progeny tests, specific S^1's and FS's were selected, increased, and crossed to a monogerm tester. This test is an evaluation of the increases of these progeny lines. Their experimental hybrids were evaluated in separate companion tests at Salinas and Brawley.

TEST 4702. EVALUATION OF MONOGERM LINES AND POPULATIONS, SALINAS, CA, 2002

48 entries x 4 reps., RCB
1-row plots, 11 ft. long

Planted: February 28, 2002
Harvested: October 3, 2002

| Variety | Description | Acre Yield | | Sucrose | Beets/100' | RJAP | Root Rot | Powdery Mildew |
		Sugar Lbs	Beets Tons	%	No.	%	%	9/30
Checks								
0833-5(Sp)A	RZM 9833-5(T-O)A	14213	39.31	18.08	161	85.0	0.0	4.5
99-790-68	Inc. U88-790-68	12509	38.90	16.08	161	83.6	0.0	3.8
00-790-15	Inc. F92-790-15	13977	44.95	15.52	166	89.1	0.0	5.0
00-790-15CMS	88-790-68CMS x C790-15	14495	47.37	15.25	157	86.5	0.0	6.0
FC monogerm lines								
01-FC123	RZM 00-FC123,19991012mmaa x A	13525	42.75	15.90	130	84.6	0.0	5.8
01-FC1014	RZM 00-FC1014mmaa x A	15036	44.75	16.85	148	82.5	0.0	5.3
01-FC1014H5	0833-5HO x " "	17772	49.99	17.75	136	87.2	0.0	5.5
01-FC123H5	0833-5HO x RZM 00-FC123	16270	46.16	17.60	130	86.0	0.0	6.0
Monogerm lines, CMS's, and F_1CMS's								
0546	Inc. 97-C546, (C546)	13137	43.54	15.02	157	84.6	0.0	4.8
0562	Inc. 97-C562, (C562)	11255	38.50	14.48	157	85.8	0.0	4.5
0911-4-10m(Sp)	Inc. 9911-4-10(C)mm, (C911-4-10)	21151	58.01	18.23	155	83.4	0.0	4.3
0911-4-10H5	9833-5HO x 9911-4-10m	14141	39.61	17.80	136	80.4	0.0	1.5
0911-4-10H50	C790-15CMS x 9911-4-10m	19434	56.04	17.38	157	84.9	0.0	4.5
0833-5H45	RZM C867-1HO x C833-5(T-O)	15505	44.35	17.42	161	84.1	0.0	6.0
0833-5HO(Sp)	RZM 9833-5(T-O)HO x ", (C833-5CMS)	14350	40.52	17.73	164	84.3	0.0	5.0
0833-5A(Sp)	Inc. 0833-5(T-O)A, (C833,-5)	12922	36.69	17.55	166	82.0	0.0	4.8
1833-5(Iso)	RZM 0833-5(Sp)(A,aa),(C833-5)	11762	33.86	17.35	164	81.7	1.3	5.8
1833-5HO(Iso)	RZM 0833-5HO x " ", (C833-5CMS)	16238	45.70	17.73	150	84.0	0.0	5.8
1833-5	Inc. 0833-5(Sp)(A,aa), (C833-5)	11623	33.06	17.60	145	82.1	0.0	5.0
1833-5HO	0833-5HO(Iso) x " ", (C833-5CMS)	14594	40.52	18.00	139	84.1	0.0	5.3
1833-5-8	Inc. 8833-5-8 (A,aa)	14140	41.08	17.23	141	81.9	0.0	4.3
1833-5-11	Inc. 8833-5-11 (A,aa)	11844	33.48	17.70	143	82.0	0.0	4.8

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Root Rot %	Powdery Mildew 9/30
Monogerm lines, CMS's, and F₁CMS's (cont.)								
1835-11	Inc. 8835-11 (A,aa)	9950	31.53	15.75	152	82.3	0.0	1.5
1835-11H5	0833-5HO x " "	17569	50.39	17.38	155	84.6	1.5	4.5
1835-26H5	8833-5HO x 0835-26	16537	48.58	16.98	148	85.3	0.0	5.5
1835-26	Inc. 8835-26 (A,aa)	13046	40.72	16.02	152	84.6	0.0	3.0
Nematode resistant monogerms								
N165-9M	Inc. N065-9 (A,aa)	5126	21.57	11.63	155	81.5	4.4	3.3
N165-9HO	NR-RZM N065H5 x N065-9	13995	48.92	14.18	132	83.3	1.7	5.0
N165-9H50	C790-15CMS x N065-9	15180	49.39	15.33	152	85.8	0.0	5.8
N165	NR-RZM N065mm(galls) (A,aa)	10633	38.70	13.75	159	84.4	0.0	4.3
N167M	Inc. N067-1(C),N066-1(galls) (A,aa)	13013	41.93	15.52	159	83.4	1.3	5.0
N167MHO	N065H5(galls) x N067-#(C)	13782	42.13	16.27	161	81.7	0.0	4.5
Monogerm populations								
1848M	RZM-ER-% 9818,0848 (A,aa)	16324	49.79	16.40	157	84.9	1.4	4.0
9869	RZM-ER-% 7869NB	15196	46.16	16.48	159	86.5	1.5	5.8
1869	RZM 0869-#s(C)aa x A,(C869)	16153	52.21	15.35	145	85.3	0.0	5.8
1869HO	9869HO x " ", (C869CMS)	15343	47.37	16.08	161	86.4	0.0	5.8
0841H7	9833-5aa x 841(C)	16629	46.97	17.67	155	86.6	0.0	5.0
0841H5	9833-5(T-O)HO x 841(C)	17141	51.80	16.55	157	84.8	0.0	4.8
1842	RZM-ER-% 9840,...mmaa x A	14394	42.13	17.05	157	83.2	0.0	4.8
1842HO(B)	0841HO,H5,... x A	16287	47.77	17.05	155	84.9	0.0	5.3
1835	RZM 0835(C)mmaa x A	16638	49.26	16.90	139	83.4	0.0	4.8
1835HO	RZM 0835HO x " "	16128	49.99	16.10	152	84.5	0.0	5.3
1836	0836,0837mmaa x A	18427	54.43	16.90	152	84.7	0.0	5.8
1836HO	0836HO x A	18926	54.22	17.48	164	85.1	0.0	5.0

TEST 4702. EVALUATION OF MONOGERM LINES AND POPULATIONS, SALINAS, CA, 2002

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Root Rot %	Powdery Mildew 9/30
Hybrid checks								
R190H5	C833-5HO x Y090	19210	53.22	18.08	127	84.6	0.0	4.8
R190H6	C833-5H50 x Y090	17279	48.38	17.85	134	84.5	0.0	4.5
R190H50	C790-15CMS x Y090	16752	50.19	16.70	132	84.3	0.0	5.3
Beta 4776R	rec'd 8-31-01	19673	54.83	17.95	155	84.1	0.0	2.5
Mean		14983.8	44.83	16.62	151.0	84.3	0.3	4.8
LSD (.05)		2821.2	7.33	1.20	16.9	3.5	2.3	1.3
C.V. (%)		13.5	11.70	5.17	8.0	2.9	599.0	18.7
F value		8.1**	7.56**	9.57**	3.2**	1.9**	0.9NS	5.3**

Notes: See Test 7002 under rhizomania. C546 & C562 are monogerm components of US H11. FC123 & FC123H5
combine Rz and Cercospora leaf spot resistance. FC1014 and FC1014H5 combine Rz and Rhizoctonia resistance.
Popns-841, -842, & -835 combine Rz with high CTV resistance. Popn-836 combines Rz with VYR. H50 = C790-15CMS
x T-O.

TEST 7002. EVALUATION OF MONOGERM LINES & POPULATIONS UNDER RHIZOMANIA, SALINAS, CA, 2002

48 entries x 4 reps., sequential
1-row plots, 11 ft. long

Planted: April 22, 2002
Harvested: October 31, 2002

| Variety | Description | Acre Yield | | Sucrose | Beets/100' | RJAP | Root Rot | Powdery Mildew |
| | | Sugar | Beets | | | | | 10/25 |
		Lbs	Tons	%	No.	%	%	
Checks								
0833-5A (Sp)	RZM 9833-5(T-O)A, (C833-5)	9376	26.23	17.90	148	84.1	7.7	5.3
99-790-68	Inc. U88-790-68, (C790-68)	6164	19.78	15.60	161	83.1	5.8	4.3
00-790-15	Inc. F92-790-15, (C790-15)	9059	28.57	15.75	170	85.2	12.3	4.3
00-790-15CMS	88-790-68CMS x C790-15	8621	27.01	16.00	159	86.2	6.3	5.3
FC monogerm lines								
01-FC123	RZM 00-FC123,19991012mmaa x A	10197	31.06	16.40	152	84.8	17.7	6.0
01-FC1014	RZM 00-FC1014mmaa x A	9156	26.61	17.10	177	81.9	4.2	5.8
01-FC1014H5[1]	0833-5HO x " "	9912	28.02	17.75	157	83.4	2.8	6.8
01-FC123H5[2]	0833-5HO x RZM 00-FC123	11417	34.07	16.83	152	82.6	10.4	6.3
Monogerm lines, CMS's and F1CMS's								
0546	Inc. 97-C546, (C546)	5595	18.69	15.00	168	81.1	9.1	5.0
0562	Inc. 97-C562, (C562)	5233	17.20	15.38	170	83.5	5.1	5.0
0911-4-10m(Sp)	Inc. 9911-4-10(C)mm, (C911-4-10)	9822	28.05	17.63	114	83.2	24.4	2.0
0911-4-10H5	9833-5HO x 9911-4-10m	13434	38.08	17.48	150	83.2	23.4	5.5
0911-4-10H50	C790-15CMS x 9911-4-10m	12544	35.90	17.52	166	85.0	23.6	4.3
0833-5H45	RZM C867-1HO x 9833-5(T-O)	10824	30.62	17.63	155	84.7	12.6	5.0
0833-5HO(Sp)	RZM 9833-5(T-O)HO x ", (C833-5CMS)	11589	32.00	18.23	148	83.6	4.2	5.0
0833-5A(Sp)	Inc. 0833-5(T-O)A, (C833-5)	9175	26.34	17.42	145	82.5	9.4	4.5
1833-5(Iso)	RZM 0833-5(Sp)(A,aa),(C833-5)	9710	27.01	17.95	168	84.3	8.0	5.0
1833-5HO(Iso)	RZM 0833-5HO x " ,(C833-5CMS)	11522	32.88	17.63	166	83.3	21.9	4.8
1833-5	Inc. 0833-5(Sp)(A,aa),(C833-5)	8077	23.38	17.25	177	80.4	1.2	5.0
1833-5HO	0833-5HO(Iso) x " ,(C833-5CMS)	10518	29.85	17.73	141	85.0	5.0	5.8
1833-5-8	Inc. 8833-5-8 (A,aa)	11861	32.12	18.48	164	84.1	8.7	4.0
1833-5-11	Inc. 8833-5-11 (A,aa)	8265	22.08	18.73	141	81.2	4.8	2.8

A63

TEST 7002. EVALUATION OF MONOGERM LINES & POPULATIONS UNDER RHIZOMANIA, SALINAS, CA, 2002

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Root Rot %	Powdery Mildew 10/25
Monogerm lines, CMS's and F₁CMS's (cont.)								
1835-11	Inc. 8835-11 (A,aa)	8304	25.80	16.23	157	81.7	7.4	1.5
1835-11H5	0833-5HO x "	12369	36.28	17.10	150	82.6	10.8	3.8
1835-26H5	8833-5HO x 0835-26	11312	32.86	17.25	152	85.1	2.9	5.0
1835-26	Inc. 8835-26 (A,aa)	8835	26.40	16.80	164	85.6	9.3	3.3
Nematode resistant monogerms								
N165-9M	Inc. N065-9 (A,aa)	7032	26.00	13.57	159	81.1	0.0	2.8
N165-9HO	NR-RZM N065H5 x N065-9	12738	41.33	15.55	127	83.6	3.3	4.0
N165-9H50	C790-15CMS x N065-9	12682	40.19	15.73	152	83.0	15.6	4.5
N165	NR-RZM N065mm(galls)(A,aa)	9502	30.36	15.70	159	84.9	6.9	3.3
N167M	Inc. N067-1(C),N066-1(galls)(A,aa)	8896	28.60	15.55	170	82.5	8.4	4.0
N167MHO	N065H5(galls) x N067-#(C)	12341	36.16	17.10	152	84.5	14.0	4.0
Monogerm populations								
1848M	RZM-ER-% 9818, 0848 (A,aa)	11659	35.17	16.63	148	82.6	15.3	5.0
9869	RZM-ER-% 7869NB	10735	34.67	15.57	159	81.7	2.8	5.3
1869	RZM 0869-#s(C)aa x A, (C869)	12320	38.10	16.30	173	85.1	1.4	6.0
1869HO	9869HO x " " , (C869CMS)	11739	36.14	16.33	164	86.2	4.4	6.5
0841H7	9833-5aa x 841(C)	13695	38.78	17.70	143	84.7	3.6	5.8
0841H5	9833-5(T-O)HO x 841(C)	13111	37.84	17.35	157	85.1	3.0	6.3
1842	RZM-ER-% 9840,...mmaa x A	11608	34.27	16.95	155	84.9	1.5	6.0
1842HO(B)	0841HO,H5,... x A	11901	35.22	17.10	161	85.1	7.0	5.8
1835	RZM 0835(C)mmaa x A	11983	35.07	17.02	161	84.0	2.9	6.0
1835HO	RZM 0835HO x "	11389	33.66	16.88	159	83.6	15.5	4.5
1836	0836,0837mmaa x A	12838	38.66	16.58	170	82.9	17.5	5.8
1836HO	0836HO x A	11769	35.28	16.77	173	84.5	2.6	6.3

TEST 7002. EVALUATION OF MONOGERM LINES & POPULATIONS UNDER RHIZOMANIA, SALINAS, CA, 2002

(cont.)

| Variety | Description | Acre Yield | | Sucrose | Beets/ 100' | RJAP | Root Rot | Powdery Mildew |
		Sugar Lbs	Beets Tons	%	No.	%	%	10/25
Hybrid checks								
Y190H5	C833-5HO x Y090	13806	40.23	17.20	105	83.3	2.5	5.3
Y190H6	C833-5H50 x Y090	12510	35.63	17.58	130	84.9	1.7	5.3
Y190H50	C790-15CMS x Y090	12051	36.16	16.73	134	85.0	11.8	5.0
Beta 4776R	rec'd 8-31-01	12413	34.55	18.00	164	86.1	1.4	2.3
Mean		10658.5	31.65	16.85	155.2	83.8	8.4	4.8
LSD (.05)		2506.2	7.46	0.99	20.1	3.6	16.6	1.4
C.V. (%)		16.8	16.86	4.19	9.3	3.1	141.4	20.8
F value		5.5**	4.83**	8.05**	4.4**	1.3NS	1.2NS	5.8**

Footnotes:

[1]01-FC1014H5 is the CMS version of the F_1 hybrid C833-5aa x FC1014. Those new monogerm populations will be advanced as FC1015 and FC1015HO. FC1014 has combined resistance to rhizomania and Rhizoctonia.

[2]01-FC123H5 is the CMS version of the F_1 hybrid C833-5aa x FC123. These new monogerm populations will be advanced as FC124 and FC124HO. FC123 has combined resistance to rhizomania and Cercospora leaf spot. C833-5 germplasm will add resistance to curly top virus, virus yellows, and bolting.

Also see Test 4702 under nondiseased conditions.

Popn-841 combines Rz and CTR from inbred lines such as C546, C562, C718, C762-17, etc.
Popn-835 combines Rz and VYR & CTR from early generation inbred lines developed at Salinas.

A65

TEST 2602.   PERFORMANCE OF COMMERCIAL HYBRIDS WITHOUT BChV INOCULATION, SALINAS, CA, 2002

24 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: February 27, 2002
Harvested: October 9, 2002

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Powdery Mildew Score	Virus Yellows 8/29	Virus Yellows Mean	Bolting %
Checks										
R176-89H5	0833-5HO x RZM R076-89	17772	50.76	17.50	144	84.7	4.6	2.8	1.5	0.0
R176-89H50	C790-15HO x RZM R076-89	18763	56.23	16.66	141	85.5	4.4	2.8	1.4	0.0
California commercial hybrids										
Phoenix	rec'd 8-16-01	21021	62.33	16.88	155	87.9	6.0	3.5	1.9	0.0
Beta 4430R	rec'd 8-31-01	21273	62.53	17.00	153	86.8	4.8	5.3	2.5	0.0
HH141	rec'd 8-16-01	19996	58.05	17.23	152	85.7	5.0	4.5	2.8	0.0
Beta 4776R	rec'd 8-31-01	18956	54.02	17.54	146	85.8	2.1	3.6	2.0	0.0
Beta 4035R	rec'd 3-10-97	17824	52.91	16.84	159	84.2	5.4	3.0	1.8	0.0
US H11	1999 production, 11-3-99	17582	53.76	16.35	147	84.4	6.9	3.1	1.9	0.0
Colorado commercial hybrids										
Monohikari	2-22-02 (Lot 8033)	17414	49.23	17.69	154	87.3	5.6	3.8	2.5	1.8
Beta 6045	2-22-02 (011218FH2)	19064	49.85	19.11	151	86.4	5.3	4.3	2.4	0.0
HM 9155	2-22-02 383-936	19675	56.03	17.58	161	85.9	5.8	3.6	2.2	0.4
HM 1639	2-22-02 515-047	17566	51.55	17.00	156	84.8	5.6	3.5	2.5	0.0
Ranger	2-22-02 (Lot 8044)	17104	50.39	17.00	155	84.4	5.8	4.1	2.6	0.4
Crystal 205	2-22-02 (0205C8602)	18138	51.95	17.45	162	86.0	5.3	5.4	3.6	0.4
Beta 4546	2-22-02 (011130FH2)	19758	53.56	18.46	160	85.1	5.9	2.5	1.5	0.0
USDA Experimental hybrids										
1929-62H5	C833-5HO x RZM 9929-62	18566	54.05	17.15	149	84.7	4.4	2.6	1.8	0.0
1929-4H5	C833-5HO x RZM 9929-4	19264	52.00	18.54	152	84.4	3.5	2.9	1.6	0.0
1930-35H5	C833-5HO x RZM 9930-35	18325	50.44	18.17	144	82.9	4.8	3.1	1.7	0.0
Y190H3	C562HO x RZM Y090	18262	52.86	17.27	136	86.2	5.9	3.1	2.0	0.0
Y190H5	C833-5HO x RZM Y090	17631	50.33	17.49	92	84.4	4.9	2.3	1.2	0.0

A66

TEST 2602. PERFORMANCE OF COMMERCIAL HYBRIDS WITHOUT BChV INOCULATION, SALINAS, CA, 2002

(cont.)

| Variety | Description | Acre Yield | | Sucrose | Beets/100' | RJAP | Powdery Mildew | Virus Yellows | | Bolting |
		Sugar Lbs	Beets Tons	%	No.	%	Score	8/29	Mean	%
USDA Experimental hybrids (cont.)										
Y190H50	C790-15CMS x RZM Y090	18576	54.67	16.99	132	86.5	4.4	2.6	1.4	0.0
Y190H2	C831-3HO x RZM Y090	17292	50.69	17.02	122	84.8	4.9	3.0	1.7	0.0
Y190H27	C831-4HO x RZM Y090	18583	55.63	16.66	135	84.9	5.5	2.8	1.7	0.0
Beta 6600	rec'd 7-11-00	18490	46.96	19.69	157	88.0	5.4	4.0	2.3	0.0
Mean		18620.7	53.37	17.47	146.3	85.5	5.1	3.4	2.0	0.1
LSD (.05)		1301.5	2.87	0.74	12.2	1.8	0.7	0.7	0.6	0.6
C.V. (%)		7.1	5.46	4.27	8.5	2.1	13.2	21.4	28.1	535.8
F value		5.7**	13.47**	9.32**	12.1**	3.7**	15.8**	10.3**	7.8**	2.7**

Notes: See Test 2202 for VY (BChV) inoculated and relative VY %loss.

Virus yellows was scored 6/27, 7/21, 8/05, & 8/29 on a scale of 0 to 9, where 9 = 90-100% of mature leaves showing yellowing symptoms. Plots were not inoculated so this VY reflects natural infection with BChV and BWYV. Natural infection was late and mild.

Powdery mildew was controlled until the end of season. PM should have had relatively little effect on yield.

Beet chlorosis virus is one of the components of VY in California and also is known to occur in other beet producing states and in Europe. For several years in the late 1990's, BChV caused significant losses in certain fields in the Northern Great Plains. Varieties listed as Colorado commercial hybrids were chosen because they were grown in the 1990s when BChV was severe or because they represent currently grown hybrids. Beta 6600 was included as a high %S, VY susceptible check.

A67

TEST 2702. PERFORMANCE OF EXPERIMENTAL HYBRIDS WITHOUT BChV INOCULATION, SALINAS, CA, 2002

24 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: February 27, 2002
Harvested: October 09, 2002

Variety	Description	Acre Yield		Sucrose	Beets/100'	RJAP	Powdery Mildew	Virus Yellows	
		Sugar Lbs	Beets Tons	%	No.	%	Score	8/29	Mean
Commercial checks									
Beta 4776R	rec'd 8-31-01	19110	54.47	17.55	154	85.6	2.6	4.3	2.3
HH141	rec'd 8-16-01	19786	57.59	17.19	148	85.8	5.4	3.8	2.1
Phoenix	rec'd 8-16-01	20620	59.91	17.21	155	87.7	5.9	3.5	1.8
Beta 4430R	rec'd 8-31-01	19978	58.80	16.98	155	87.1	4.6	5.1	2.5
Susceptible check									
Crystal 205	2-22-02 (Lot 0205 C8602)	18963	51.18	18.52	155	85.2	4.8	5.3	3.1
Resistant checks									
R176-89-H50	C790-15CMS x RZM R076-89	18136	55.17	16.45	143	85.7	4.3	2.6	1.5
Y169H50	C790-15CMS x RZM-ER-% Y969,(C69)	19728	55.48	17.80	151	85.6	3.6	2.9	1.5
Y190H50	C790-15CMS x RZM Y090	18867	53.50	17.64	128	85.6	5.0	2.8	1.5
MM,S^f,Aa populations									
1931H50	C790-15CMS x RZM 0931,(popn-931)	18740	55.73	16.80	151	84.0	5.0	2.9	1.5
1941H50	C790-15CMS x RZM 0941,(popn-941)	19317	55.35	17.42	144	85.0	4.4	2.6	1.4
Hybrids with S$_1$ pollinators									
0931-19H50	C790-15CMS x 8930-19, (C930-19)	19210	56.38	17.01	154	85.2	3.8	2.6	1.4
1927-4H50	C790-15CMS x RZM 9927-4, (C927-4)	20180	58.30	17.31	151	85.9	5.6	2.6	1.4
1929-62H50	C790-15CMS x RZM 9929-62, (C929-62)	19354	58.00	16.67	150	85.0	4.8	2.6	1.4
1930-35H50	C790-15CMS x RZM 9930-35, (C930-35)	18883	53.26	17.74	152	85.0	4.8	3.1	1.8
1929-4H50	C790-15CMS x RZM 9929-4	19560	54.42	17.98	152	84.4	4.4	2.4	1.3
1924-2H50	C790-15CMS x RZM 9924-2	18385	52.10	17.66	152	85.4	3.8	2.3	1.3

A68

(cont.)

Variety	Description	Acre Yield Sugar lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Powdery Mildew Score	Virus Yellows 8/29	Virus Yellows Mean
Hybrids with FS pollinators									
Y168-16H50	C790-15CMS x Y968-16	19877	55.68	17.85	153	86.5	3.6	3.1	1.8
R181-22H50	C790-15CMS x R981-22	20092	56.59	17.76	148	86.0	4.4	2.9	1.3
R178-6H50	C790-15CMS x R978-6	21128	60.06	17.58	155	86.9	5.6	3.0	1.5
R180-11H50	C790-15CMS x R980-11	19684	54.92	17.90	149	85.3	5.3	2.9	1.8
R176-89-5-4H50	C790-15CMS x R976-89-5-4	20523	57.14	17.99	148	85.7	4.6	2.3	1.2
Y167-5H50	C790-15CMS x Y967-5	20269	56.43	17.96	155	86.0	4.0	2.9	1.5
Y172-1H50	C790-15CMS x Y972-1	19782	55.88	17.66	157	83.9	6.0	2.9	1.6
Y175-13H50	C790-15CMS x Y975-13	18296	52.91	17.31	148	85.7	5.0	2.8	1.4
Mean		19519.6	55.80	17.50	150.4	85.6	4.7	3.1	1.7
LSD (.05)		1315.9	2.84	0.70	10.3	2.0	0.7	0.6	0.4
C.V. (%)		6.8	5.17	4.08	7.0	2.4	13.9	20.8	23.9
F value		2.6*	5.09**	3.66**	2.5**	1.5NS	12.7**	12.1**	9.8**

Notes: See Test 2302 for VY (BChV) inoculated and relative VY %loss.

Virus yellows was scored 6/26, 7/21, 8/05, & 8/29 on a scale of 0 to 9, where 9 = 90-100% of mature leaves showing yellowing symptoms. Plots were not inoculated so this VY reflects natural infection with BChV and BWYV. Natural infection was late and mild.

Powdery mildew was controlled until the end of season. PM should have had relatively little effect on yield.

A69

TEST 2902. EVALUATION OF TOPCROSS HYBRIDS WITH POPN-931, SALINAS, CA, 2002

12 entries x 8 reps., RCB
1-row plots, 22 ft. long

Planted: February 27, 2002
Harvested: October 8, 2002

Variety	Description	Acre Yield		Sucrose	Beets/ 100'	RJAP	Root Rot	Powdery Mildew
		Sugar Lbs	Beets Tons	%	No.	%	%	Score
Check								
Beta 4776R	rec'd 8-31-01	19586	53.91	18.19	153	87.9	0.0	2.9
Topcrosses to popn-931								
1931H50	C790-15CMS x RZM 0931	20582	59.66	17.24	149	85.8	0.0	5.1
1931H5	0833-5HO x RZM 0931	19272	54.03	17.85	133	84.3	0.5	4.4
1931H6	0833-5H50 x RZM 0931	19064	55.12	17.27	136	84.6	0.0	5.0
1931H2	9831-3HO x RZM 0931	19067	53.41	17.85	135	85.2	0.4	4.6
1931H27	9831-4HO x RZM 0931	19370	57.49	16.85	137	83.2	0.0	5.1
1931H28	0831-4-7HO x RZM 0931	20809	58.65	17.73	135	85.5	0.0	5.3
1931H29	0831-4-10HO x RZM 0931	19953	57.98	17.16	135	83.3	0.0	5.1
1931H62	0836-1H5 x RZM 0931	18877	53.36	17.69	137	84.7	0.0	5.0
1931H63	0836-7H5 x RZM 0931	18989	54.37	17.45	132	84.9	0.0	4.0
1931H64	0834-2H5 x RZM 0931	18266	52.59	17.35	139	84.5	0.4	6.0
1931H67	0837-6H5 x RZM 0931	19375	53.46	18.11	135	85.3	0.0	5.3
Mean		19434.2	55.34	17.56	138.1	85.0	0.1	4.8
LSD (.05)		1522.6	3.66	0.65	10.2	2.0	0.6	0.8
C.V. (%)		7.9	6.63	3.70	7.4	2.3	556.3	16.7
F value		1.8NS	3.49**	3.12**	3.0**	3.1**	0.9NS	7.7**

Notes: Evaluation of early generation monogerm lines: 0833-5HO = C833-5CMS; 0833-5H50 = C790-15CMS x C833-5; 9831-3HO = C831-3CMS; 9831-4HO = C831-4CMS; H5 = C833-5CMS x T-O. 0931 = popn-931 = MM,S^f,Aa,Rz random-mating population.

TEST 3002. EVALUATION OF TOPCROSS HYBRIDS WITH Y90, SALINAS, CA, 2002

24 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: February 27, 2002
Harvested: October 8, 2002

| Variety | Description | Acre Yield | | Sucrose | Beets/100' | RJAP | Root Rot | Powdery Mildew |
		Sugar Lbs	Beets Tons	%	No.	%	%	Score
Check								
Beta 4430R	rec'd 8-31-01	19977	58.60	17.02	153	86.7	0.0	3.4
Phoenix	rec'd 8-16-01	20698	59.71	17.31	157	88.9	0.4	5.5
Topcrosses to Y90								
Y190H50	C790-15CMS x Y090	18358	52.20	17.59	127	84.6	0.5	3.9
Y190H5	C833-5HO x Y090	17095	48.49	17.61	104	85.1	0.0	4.5
Y190H6	C833-5H50 x Y090	18658	51.68	18.05	130	84.3	0.5	4.0
Y190H45	C867-1HO x Y090	18259	51.45	17.75	134	85.5	0.0	3.6
Y190H2	C831-3HO x Y090	17494	50.53	17.31	124	84.5	0.0	4.4
Y190H27	C831-4HO x Y090	19132	54.81	17.44	128	84.2	0.0	4.4
Y190H7	C833-5(Sp)aa x Y090	18189	50.24	18.10	127	84.7	0.0	4.6
Y190H29	0831-4-10HO x Y090	19155	54.32	17.65	128	84.7	0.0	4.5
Y190H62	0836-1H5 x Y090	18106	51.31	17.65	118	84.0	0.0	4.0
Y190H63	0836-7H5 x Y090	18973	53.01	17.90	125	84.1	0.0	3.9
Y190H64	0834-2H5 x Y090	17380	49.63	17.51	128	85.7	0.0	5.6
Y190H67	0837-6H5 x Y090	18101	51.15	17.71	140	84.8	0.0	4.8
Y190H82	C833-5H2 x Y090	17773	50.27	17.70	127	83.6	0.0	4.5
Y190H83	C833-5H27 x Y090	18588	52.11	17.81	117	83.9	0.0	3.9
Y190H84	C833-5H45 x Y090	19359	53.92	17.95	140	83.4	0.0	5.0
Y190H85	C833-5H46 x Y090	18891	52.76	17.90	135	84.8	0.0	5.5
Y190H3	97-C562HO x Y090	18073	50.54	17.86	139	84.7	0.0	5.1
Y190H46	9869-6HO x Y090	18235	52.76	17.30	131	85.6	0.0	6.0

TEST 3002. EVALUATION OF TOPCROSS HYBRIDS WITH Y90, SALINAS, CA, 2002

(cont.)

| Variety | Description | Acre Yield | | Sucrose | Beets/ 100' | RJAP | Root Rot | Powdery Mildew |
		Sugar Lbs	Beets Tons	%	No.	%	%	Score
Population hybrids Y90 (cont.)								
Y190H55	0835HO x Y090	18987	53.08	17.90	132	84.5	0.0	4.9
Y190H56	0836HO x Y090	19547	54.72	17.84	139	86.3	0.0	5.9
Y190H70	9869HO x Y090	19391	55.01	17.60	138	85.5	0.0	5.5
Y190H51	0841HO x Y090	17358	49.08	17.54	139	86.0	0.0	4.6
Mean		18574.0	52.56	17.67	131.6	85.0	0.1	4.7
LSD (.05)		1788.8	4.66	0.59	10.3	1.9	0.5	0.7
C.V. (%)		9.8	9.01	3.41	8.0	2.2	810.9	15.5
F value		1.9*	2.65**	1.51NS	8.9**	3.0**	0.9NS	8.3**

Notes: Evaluation of early generation monogerm lines and their F₁CMS hybrids: Y090 = MM,OP line from recombined FS families = Cycle 1, Syn 1; 0833-5HO = C833-5CMS; 0833-5H50 = C790-15CMS x C833-5; H5 = C833-5CMS x T-O; H2 = C831-3CMS x T-O; H27 = C831-4CMS x T-O; H45 = C867-1CMS x T-O; H46 = 9869-6CMS x T-O.

TEST 3102. EVALUATION OF HYBRIDS WITH S_1 PROGENY LINE POLLINATORS, SALINAS, CA, 2002

Planted: February 27, 2002
Harvested: October 7, 2002

48 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Bolting %	Powdery Mildew Score
Test 3102-1: 16V x 8R, RCB(e)								
Checks								
HH 141	rec'd 8-16-01	20264	56.43	17.96	160	85.6	0.0	5.8
Phoenix	rec'd 8-16-01	19744	56.84	17.34	166	87.4	0.0	6.1
Beta 4776R	rec'd 8-31-01	19895	54.87	18.13	160	85.4	0.0	2.8
Beta 4430R	rec'd 8-31-01	19501	55.98	17.42	161	85.0	0.0	4.5
Retests & new seed productions								
CR009-1H50	C790-15CMS x CR909-1 (CR09-1)	20019	57.64	17.36	156	83.2	2.1	5.6
Z025-9H50	x Z825-9 (CZ25-9)	18684	50.49	18.54	158	83.4	0.0	3.0
0930-19H50	x 8930-19 (C930-19)	19655	55.48	17.71	155	85.0	0.0	3.6
1930-19H50	x NB 8930-19 (C930-19)	19361	55.63	17.40	164	84.3	0.0	3.0
1927-4H50	C790-15CMS x RZM 9927-4 (C927-4)	19961	57.49	17.36	151	83.7	0.0	5.6
1929-62H50	x RZM 9929-62 (C929-62)	18293	54.97	16.65	148	84.0	0.0	3.9
1930-35H50	x RZM 9930-35 (C930-35)	19105	53.36	17.92	156	84.1	0.0	4.6
1929-4H50	x RZM 9929-4	20055	55.43	18.09	155	83.7	0.0	4.6
1924-2H50	x RZM 9924-2	18789	54.40	17.25	152	84.0	0.0	3.6
0936-10H50	x 8936-10	20163	57.79	17.45	155	84.2	0.0	4.3
0936-16H50	C790-15CMS x 8936-16	18787	50.64	18.52	158	84.4	0.0	3.4
9929-45H50	x 7929-45VY	18690	54.67	17.09	152	83.5	0.0	4.1
Mean		19435.4	55.13	17.64	157.0	84.4	0.1	4.3
LSD (.05)		1248.0	3.12	0.64	7.7	1.7	0.6	0.7
C.V. (%)		6.5	5.72	3.65	5.0	2.1	460.1	16.4
F value		2.0NS	3.77*	5.20**	3.0**	3.0**	6.0**	18.5**

TEST 3102. EVALUATION OF HYBRIDS WITH S_1 PROGENY LINE POLLINATORS, SALINAS, CA, 2002
48 entries x 8 reps., RCB(e). ANOVA across tests to compare means.

		Sugar Lbs	Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Bolting %	Mildew Score
Mean		19297.9	54.49	17.72	157.0	83.7	0.5	4.6
LSD (.05)		1211.7	2.99	0.59	11.3	1.8	1.2	0.7
C.V. (%)		6.4	5.57	3.35	7.3	2.2	274.5	15.1
F value		3.9**	6.58**	4.56**	1.6*	2.8**	14.5**	13.9**

TEST 3102. EVALUATION OF HYBRIDS WITH S_1 PROGENY LINE POLLINATORS, SALINAS, CA, 2002

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Bolting %	Powdery Mildew Score
Test 3102-2: 16V x 8R, RCB(e)								
Checks								
1931H50(Iso)	C790-15CMS x RZM-ER-% 9931	20615	60.01	17.16	157	82.9	0.0	4.9
1931H50(Sp)	x 9931(C)	18478	52.81	17.50	148	82.3	0.0	5.0
1941H50(Iso)	x RZM-ER-% 9941	19515	55.93	17.46	156	83.4	0.0	4.9
1941H50(Sp)	x 9941(C)	18806	53.41	17.60	157	85.4	0.8	4.8
Selected S_1 lines								
1931-56H50	C790-15CMS x 9931-56	21511	60.00	17.94	150	83.4	0.0	2.6
1931-201H50	x 9931-201	20656	57.39	18.02	163	85.1	0.0	3.9
1935-6H50	x 9935-6	18940	53.01	17.85	161	83.0	0.0	3.3
1936-14H50	x 9936-14	20861	58.70	17.77	159	83.9	0.0	4.1
Check								
Z125H50	C790-15CMS x Z025(C)	19472	54.91	17.74	157	83.6	0.0	5.3
Selected S_1 lines								
Z131-14H50	C790-15CMS x Z931-14	20362	54.87	18.55	157	84.5	0.0	5.1
Z131-18H50	x Z931-18	20260	56.69	17.88	159	82.4	0.0	3.5
1942H50	x RZM 0942	19544	56.74	17.21	157	83.4	0.0	4.1
Check								
CR111H50	C790-15CMS x CR11(C)	18630	54.52	17.08	155	83.7	0.0	5.3
Selected S_1 lines								
CR110-14-2H50	C790-15CMS x CR910-14-2	18419	52.05	17.69	161	83.2	8.3	5.0
CR110-5H50	x CR910-5	18417	51.53	17.86	154	83.1	0.0	5.1
CR112-5H50	x CR812-5	19918	57.64	17.29	156	83.2	0.4	5.8
Mean		19650.2	55.64	17.66	156.8	83.5	0.6	4.5
LSD (.05)		1163.0	2.79	0.53	6.8	2.0	1.5	0.7
C.V. (%)		6.0	5.07	3.03	4.4	2.4	256.0	14.6
F value		5.6**	7.32**	4.00**	2.5**	1.5NS	14.7**	13.5**

A74

TEST 3102. EVALUATION OF HYBRIDS WITH S_1 PROGENY LINE POLLINATORS, SALINAS, CA, 2002
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Bolting %	Powdery Mildew Score
Test 3102-3:	16V x 8R, RCB(e)							
Population hybrids								
1932H50	C790-15CMS x RZM-ER-% 9932	19848	56.94	17.44	155	83.8	0.0	5.6
1933H50	x RZM-ER-% 9933	19350	54.72	17.69	166	83.4	8.2	5.6
N124H50	x NR-RZM N024	18783	53.76	17.48	161	84.0	0.0	4.8
FC1030H50	x FC1030(C)	18430	53.21	17.31	166	84.5	1.3	5.3
Testcross hybrids to C833-5CMS								
1931H5	0833-5HO x 0931	19261	53.66	17.95	145	82.9	0.0	5.0
1941H5	x 0941	18354	51.07	17.98	147	83.1	0.0	4.5
1942H5	x RZM 0942	18062	50.83	17.76	153	82.0	0.0	4.3
FC1030H5	x FC1030(C)	18425	51.60	17.86	161	83.3	0.3	5.9
CR111H5	x CR11(C)	18564	52.41	17.73	156	81.4	0.4	5.3
Z125H5	x Z025(C)	17489	49.33	17.71	150	82.7	0.0	4.8
0930-19H5	9833-5HO x 8930-19 (C930-19)	19491	53.70	18.17	165	85.3	0.0	4.1
1930-35H5	0833-5HO x RZM 9930-35 (C930-35)	18943	50.64	18.67	159	82.8	0.0	5.4
1927-4H5	x RZM 9927-4 (C927-4)	19971	57.09	17.51	163	83.4	0.0	5.9
1929-62H5	x RZM 9929-62 (C929-62)	19358	55.33	17.52	159	83.8	0.0	3.9
1929-4H5	x RZM 9929-4	18991	50.44	18.85	155	82.7	0.0	3.5
1924-2H5	x RZM 9924-2	17612	48.52	18.15	158	82.5	0.0	4.4
Mean		18808.2	52.70	17.86	157.4	83.2	0.6	4.9
LSD (.05)		1139.0	3.01	0.51	7.7	1.6	1.4	0.6
C.V. (%)		6.1	5.76	2.90	4.9	1.9	217.9	11.9
F value		3.2**	5.62**	5.56**	5.7**	2.9**	17.2**	12.5**

Notes: Usually line numbers prefixed with "C" have been released.

Grown in an area following methyl bromide fumigation and strawberry production. No soil-borne problems were observed. Natural VY infection was light to moderate. PM was controlled until very late in the season. Downy mildew was mild on most entries.

Also see test 7902 for performance under rhizomania and B302 & B502 for performance in Imperial Valley.

TEST 3202. RETEST OF S₁mmaa x C78 TOPCROSSES FROM 2000, SALINAS, CA, 2002

12 entries x 8 reps., RCB
1-row plots, 22 ft. long

Planted: February 27, 2002
Harvested: September 24, 2002

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Bolting %	RJAP %	Powdery Mildew 9/23
Checks								
Beta 4776R	rec'd 8-31-01	18357	53.11	17.29	166	0.0	85.5	1.6
R078H50	C790-15CMS x R978 (C78/2)	17906	53.41	16.74	165	0.0	84.2	3.5
R078H5	9833-5(T-O)HO x R978	17120	49.63	17.25	162	0.0	84.0	2.9
Retests of S₁mm lines								
R078H10-17	9810-17aa x R978 (C78/2)	16620	50.03	16.64	165	0.0	83.8	3.3
R078H10-19	9810-19aa x R978	16443	49.23	16.69	160	0.0	83.9	4.5
R078H48-1	9848-1aa x R978	17869	52.40	17.05	143	0.0	84.0	5.4
R078H69-9	9869-9aa x R978	18177	53.61	16.96	163	0.0	85.0	4.8
R078H35-8	9835-8aa x R978	17697	52.45	16.85	161	0.0	83.5	5.3
R078H35-10	9835-10aa x R978	17984	52.10	17.25	158	0.0	85.1	4.0
R078H35-3	9835-3aa x R978	17607	52.15	16.91	161	0.3	84.5	4.9
R078H36-4	9836-4aa x R978	14911	45.87	16.15	134	0.0	82.8	3.6
R078H36-13	9836-13aa x R978	16855	50.99	16.50	153	0.0	82.9	3.6
Mean		17295.4	51.25	16.86	157.7	0.03	84.1	3.9
LSD (.05)		1589.6	3.65	0.86	14.0	0.28	1.8	0.8
C.V. (%)		9.2	7.16	5.12	8.9	979.80	2.1	21.5
F value		3.0**	2.98**	1.24NS	4.0**	1.00NS	1.7*	13.2**

Notes: In 1999, S₁ progenies from Sᶠ, monogerm populations were produced and tested for O-type. In 2000, the S₁ progenies were rogued to genetic male steriles and topcrossed to C78/2. On the basis of topcross hybrid tests in 2001, selected topcross hybrids were retested in 2002 at Salinas and Brawley. S₁'s from populations 810 and 840 have resistance to rhizomania from C51 (*Bvm*). Popn 835 has good curly top resistance. Popn 836 was developed for resistance to virus yellows. Also see test 8002 under rhizomania.

TEST 3302. EVALUATION OF TESTCROSS HYBRIDS TO C833-5CMS, SALINAS, CA, 2002

24 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: February 27, 2002
Harvested: September 23, 2002

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Root Rot %	RJAP %	Powdery Mildew 9/23
Checks								
Phoenix	rec'd 8-16-01	19108	56.99	16.73	168	0.0	87.0	4.9
Beta 4776R	rec'd 8-31-01	18472	51.50	17.91	162	0.0	85.5	1.6
Beta 4430R	rec'd 8-31-01	18584	54.87	16.90	160	0.4	86.2	3.6
HH141	rec'd 8-16-01	19100	55.03	17.34	159	0.0	86.8	4.9
Testcrosses with lines & populations								
R078H5	9833-5(T-O)HO x R978 (C78/2)	18013	52.20	17.24	159	0.0	83.3	2.9
Y190H5	0833-5HO x RZM Y090	16350	45.97	17.77	107	0.0	83.4	3.6
Y175H5	0833-5HO x RZM Y075	16514	47.97	17.16	143	0.0	82.0	3.3
R176-89H5	0833-5HO x R076-89	17649	50.54	17.45	156	0.0	84.2	2.9
1942H5	0833-5HO x RZM 0942	17490	49.67	17.60	155	0.0	82.6	2.9
01-FC1030H5	0833-5HO x FC1030(C)	17477	49.53	17.65	155	0.0	83.4	4.0
1931H5	0833-5HO x RZM 0931(C)	17830	50.50	17.66	147	0.0	83.5	3.9
1941H5	0833-5HO x RZM 0941(C)	17535	50.44	17.41	157	0.0	83.8	3.3
CR111H5	0833-5HO x RZM CR011(C)	18069	52.23	17.30	153	0.0	81.7	3.6
Z125H5	0833-5HO x RZM Z025	17665	48.81	18.09	150	0.0	83.2	3.3
Testcrosses with progeny lines								
Z025-9H5	9833-5HO x Z825-9 (CZ25-9)	18167	49.88	18.20	165	0.0	82.2	2.5
CR009-1H5	9833-5HO x CR909-1 (CR09-1)	17991	50.79	17.71	161	0.0	82.7	3.8
0930-19H5	9833-5HO x 8930-19 (C930-19)	18731	52.76	17.76	164	0.0	84.8	2.9
0929-112H5	9833-5HO x 8929-112	18585	51.80	17.94	162	0.0	83.2	4.5
0929-114H5	9833-5HO x 8929-114	18570	51.04	18.21	157	0.0	82.9	2.9
1929-4H5	0833-5HO x RZM 9929-4	18050	49.53	18.23	159	0.0	82.4	2.4

A77

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Root Rot %	RJAP %	Powdery Mildew 9/23
Testcrosses with progeny lines (cont.)								
1929-62H5	0833-5HO x RZM 9929-62 (C929-62)							
		18089	51.85	17.44	154	0.0	83.6	3.1
1930-35H5	0833-5HO x RZM 9930-35 (C930-35)							
		17621	48.67	18.10	152	0.0	81.8	3.6
1924-2H5	0833-5HO x RZM 9924-2	17066	47.21	18.08	159	0.0	83.8	3.3
1927-4H5	0833-5HO x RZM 9927-4 (C927-4)							
		18673	54.32	17.17	157	0.0	83.5	4.1
Mean		17974.9	51.00	17.63	155.0	0.02	83.6	3.4
LSD (.05)		1315.0	3.08	0.61	12.0	0.22	1.7	0.8
C.V. (%)		7.4	6.13	3.50	7.9	1367.30	2.0	23.6
F value		2.3**	5.44**	3.76**	7.3**	1.00NS	5.9**	7.3**

Notes: 9833-5(T-O)HO and 0833-5HO = C833-5CMS. Also see test 8102 under mild rhizomania.

TEST 3402. EVALUATION OF HYBRIDS WITH SELF-STERILE POLLINATORS, SALINAS, CA, 2002

48 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: February 27, 2002
Harvested: September 24, 2002

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Acre Yield Sucrose %	Beets/100' No.	Root Rot %	Bolting %	RJAP %	Powdery Mildew 9/23
Test 3402-1: 16V x 8R, RCB(e)									
Checks									
Beta 4776R	rec'd 8-31-01	17651	49.18	17.95	160	-.-	-.-	86.9	1.8
Beta 4430R	rec'd 8-31-01	19690	56.84	17.35	165	-.-	-.-	88.5	4.0
Phoenix	rec'd 8-16-01	19460	58.08	16.71	161	-.-	-.-	87.6	5.3
HH 141	rec'd 8-16-01	19060	54.17	17.63	156	-.-	-.-	86.6	5.1
Hybrids with FS lines									
R178H50	C790-15CMS x RZM-ER-% R978	18104	52.45	17.25	156	-.-	-.-	84.8	4.4
R178-5H50	x R978-5	17158	49.63	17.30	159	-.-	-.-	85.5	3.6
R178-6H50	x R978-6	19287	54.52	17.70	165	-.-	-.-	86.1	5.0
R178-11H50	x R978-11	17695	52.20	16.96	169	-.-	-.-	84.0	4.0
Y169H50	C790-15CMS x RZM-ER-% Y969	17933	51.85	17.30	162	-.-	-.-	85.5	3.6
Y168-8H50	x Y968-8	18118	51.85	17.48	160	-.-	-.-	86.3	3.3
Y168-13H50	x Y968-13	17961	51.09	17.60	160	-.-	-.-	85.8	3.0
Y168-16H50	x Y968-16	18250	52.81	17.29	165	-.-	-.-	84.1	3.3
R180H50	C790-15CMS x RZM-ER-% R980	19008	54.02	17.59	159	-.-	-.-	86.0	4.5
R180-11H50	x R980-11	18764	52.96	17.73	162	-.-	-.-	84.9	4.3
R180-16H50	x R980-16	17494	50.89	17.17	157	-.-	-.-	85.3	4.5
R180-21H50	x R980-21	19202	53.66	17.89	164	-.-	-.-	85.1	4.3
Mean		18427.2	52.89	17.43	161.4			85.8	4.0
LSD (.05)		1204.7	3.13	0.63	8.7	0.05	0.04	2.0	0.7
C.V. (%)		6.6	5.97	3.67	5.4	0.38	0.38	2.4	17.7
F value		3.3**	4.45**	2.11*	1.4NS			2.7*	12.9**

TEST 3402. EVALUATION OF HYBRIDS WITH SELF-STERILE POLLINATORS, 2002
48 entries x 8 reps., RCB(E). ANOVA across tests to compare means.

		Sugar Lbs	Beets Tons	Sucrose %	Beets/100' No.	Root Rot %	Bolting %	RJAP %	Powdery Mildew
Mean		18297.8	52.45	17.45	161.8			85.3	4.1
LSD (.05)		1291.6	3.04	0.75	9.4	732.80	1008.90	3.0	0.8
C.V. (%)		7.2	5.87	4.38	5.9			3.6	18.6
F value		2.5**	3.27**	1.83**	3.3**	1.23NS	1.61*	1.5*	7.5**

A79

TEST 3402. EVALUATION OF HYBRIDS WITH SELF-STERILE POLLINATORS, SALINAS, CA, 2002

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Root Rot %	Bolting %	RJAP %	Powdery Mildew 9/23
Test 3402-2: 16V x 8R, RCB(e)									
R176-89H50	C790-15CMS x R076-89	17261	50.09	17.23	149	0.4	-:-	86.4	4.3
R176-89-5H50	x RZM R076-89-5	19054	54.02	17.64	162	0.0	-:-	86.1	4.4
R176-89-5-4-H50	x R976-89-5-4	19555	54.65	17.91	164	0.0	-:-	85.8	4.0
R176-89-5NB-4H50	x R976-89-5NB-4	18053	50.74	17.80	160	0.0	-:-	86.9	3.4
R176-89-5-13H50	x R976-89-5-13	17978	50.64	17.75	159	0.0	-:-	84.9	4.4
R181-22H50	x R981-22	19455	54.35	17.92	162	0.0	-:-	85.9	3.6
Y167H50	x RZM-ER-% Y967	18139	51.99	17.45	155	0.0	-:-	85.6	3.9
Y167-5H50	x Y967-5	17982	52.05	17.26	160	0.0	-:-	83.5	3.4
Y171H50	C790-15CMS x RZM-ER-% Y971	17959	51.19	17.55	155	0.0	-:-	85.7	5.3
Y172-1H50	x Y972-1	18611	53.26	17.48	162	0.4	-:-	83.2	4.9
Y172-5H50	x Y972-5	17837	50.24	17.76	158	0.0	-:-	86.3	3.8
Y172-7H50	x Y972-7	17527	50.99	17.19	159	0.0	-:-	85.0	4.4
Y175H50	C790-15CMS x Y075	16878	49.43	17.10	149	0.0	-:-	85.3	4.5
Y175-13H50	x Y975-13	17470	51.04	17.10	161	0.7	-:-	81.4	3.8
Y190H50	x Y090	17839	50.55	17.65	142	0.0	-:-	85.5	3.8
R170H50	x RZM-ER-% R970	17533	51.38	17.04	156	0.0	-:-	84.2	4.8
Mean		18070.6	51.66	17.49	157.1	0.1		85.1	4.1
LSD (.05)		1267.4	3.18	0.67	6.4	0.5		3.3	0.7
C.V. (%)		7.1	6.22	3.84	4.1	546.8		3.9	16.9
F value		2.8**	1.98*	1.63NS	6.6**	1.4NS		1.4	4.8**

TEST 3402. EVALUATION OF HYBRIDS WITH SELF-STERILE POLLINATORS, SALINAS, CA, 2002
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Acre Yield Sucrose %	Beets/ 100' No.	Root Rot %	Bolting %	RJAP %	Powdery Mildew 9/23
Test 3402-3: 16V x 8R, RCB(e)									
Hybrids with FS lines									
P129H50	C790-15CMS x PMR-RZM P029-#(C)	18346	52.92	17.34	169	0.0	0.0	84.9	4.0
P130H50	x PMR-RZM P030-#(C)	18500	52.50	17.60	164	0.0	0.0	85.0	3.6
P118-6H50	x P918-6	19025	56.13	16.94	167	0.0	0.0	84.3	5.3
P125-12H50	x P925-12	17444	48.42	18.01	161	0.3	0.0	85.2	3.6
P007/8H50	x PMR-RZM P807,P808	18766	53.56	17.52	169	0.0	0.0	86.3	2.6
R143H50	C790-15CMS x RZM-ER-% R943	17318	50.59	17.13	167	0.0	0.0	84.8	3.8
R140H50	x RZM-ER-% R940,R954	18125	52.00	17.42	170	0.0	0.0	83.2	4.0
Retests from 2000 seed									
R078-4H50	C790-15CMS x R878-4	17769	53.51	16.63	169	0.0	0.0	85.4	3.6
R078-8H50	x R878-8	17915	51.70	17.30	162	0.0	0.0	84.6	4.6
Y067-3H50	x Y867-3	18263	51.85	17.60	160	0.0	0.0	87.1	4.8
R080-9H50	x R880-9	17812	54.10	16.48	166	0.0	0.0	81.9	3.6
Y069-18H50	x Y869-18	18742	53.56	17.49	166	0.0	0.0	86.5	3.6
R080/2-9H50	C790-15CMS x R880/2-9	19494	53.73	18.14	177	0.0	0.0	84.5	5.4
R080/2-11H50	x R880/2-11	19456	54.32	17.91	170	0.0	0.3	85.7	5.0
R080-45-10H50	x R880-45-10	18786	53.91	17.41	169	0.0	0.0	85.2	3.4
Y072-4H50	x Y872-4	18565	52.10	17.82	167	0.3	1.1	85.5	4.4
Mean		18395.5	52.81	17.42	167.1	0.04	0.1	85.0	4.1
LSD (.05)		1300.3	2.65	0.89	7.5	0.34	0.6	3.6	0.8
C.V. (%)		7.1	5.07	5.16	4.5	813.13	689.8	4.3	20.4
F value		2.0*	3.45**	2.13*	2.3**	0.92NS	1.7NS	1.0NS	6.6**

Notes: Evaluation of full-sib lines in testcross hybrids. FS's were extracted from lines such as C78/2, C80 & C76-89-5; C72, Y75, & C67 with resistance from C51 (*Bvm*); and P#'s with PMR from WB97 & WB242. Following FS progeny evaluations, selected FS's were testcrossed to C790-15CMS t evaluate hybrid performance.

Also see tests B202 & B602 at Brawley, 7802 under rhizomania, and 402 for nonbolting evaluation.

TEST 2202. PERFORMANCE OF COMMERCIAL HYBRIDS UNDER BChV INOCULATION, SALINAS, CA, 2002

24 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: February 27, 2002
Harvested: October 15, 2002
Inoc. BChV: May 9, 2002

| Variety | Description | Acre Yield | | | Sucrose % | Beets/100' No. | RJAP % | Powdery Mildew Score | Virus Yellows | | | |
		Sugar Lbs	Loss[1] %	Beets Tons					6/26	8/5	8/29	Mean
Checks												
R176-89H5	0833-5HO x RZM R076-89	15953	10.23	47.98	16.58	141	84.1	3.6	1.6	3.0	4.4	3.1
R176-89H50	C790-15HO x RZM R076-89	16638	11.33	52.50	15.84	151	84.7	4.1	1.4	2.9	4.0	2.9
California commercial hybrids												
Phoenix	rec'd 8-16-01	15324	27.10	47.92	15.98	164	87.5	5.4	4.3	5.3	5.6	5.0
Beta 4430R	rec'd 8-31-01	13714	35.54	45.20	15.19	160	85.0	4.6	4.9	7.3	7.8	6.6
HH141	rec'd 8-16-01	14254	28.71	44.79	15.84	162	85.9	5.9	5.1	5.9	7.0	6.0
Beta 4776R	rec'd 8-31-01	16267	14.18	47.82	16.98	156	85.5	2.6	4.5	5.8	6.4	5.5
Beta 4035R	rec'd 3-10-97	14305	19.74	45.00	15.91	169	82.7	5.9	3.3	4.4	4.9	4.3
US H11	1999 production,11-3-99	15255	13.23	49.60	15.38	156	84.7	8.0	2.1	4.1	5.0	3.9
Colorado commercial hybrids												
Monohikari	2-22-02 (Lot 8033)	12635	27.44	37.39	16.90	150	85.8	4.9	4.3	5.3	6.0	5.2
Beta 6045	2-22-02 (011218FH2)	14075	26.17	38.90	18.10	164	86.9	5.0	3.8	5.9	7.0	5.6
HM 9155	2-22-02 383-936	15923	19.07	47.77	16.66	163	85.1	5.5	3.9	5.1	6.5	5.2
HM 1639	2-22-02 515-047	11790	32.88	37.97	15.50	155	84.7	5.8	4.8	6.6	7.1	6.2
Ranger	2-22-02 (Lot 8044)	13937	18.52	42.28	16.46	155	84.5	5.5	4.3	5.4	6.1	5.3
Crystal 205	2-22-02 (0205C8602)	13889	23.43	40.97	16.99	153	84.9	4.8	4.4	6.0	7.3	5.9
Beta 4546	2-22-02 (011130FH2)	18078	8.50	50.03	18.08	166	85.2	6.3	2.0	3.3	4.3	3.3
USDA Experimental hybrids												
1929-62H5	C833-5HO x RZM 9929-62	14877	19.87	46.52	15.99	142	84.2	3.1	2.4	3.8	4.4	3.7
1929-4H5	C833-5HO x RZM 9929-4	16530	14.20	46.67	17.71	142	83.9	2.6	3.4	4.1	5.4	4.4
1930-35H5	C833-5HO x RZM 9930-35	16292	11.10	46.41	17.55	158	83.3	4.5	2.4	4.8	5.1	4.2
Y190H3	C562HO x RZM Y090	15634	14.39	47.19	16.58	131	85.0	5.4	2.6	4.8	5.4	4.4
Y190H5	C833-5HO x RZM Y090	15397	12.67	45.63	16.84	98	84.2	4.5	1.8	4.1	4.9	3.7

A82

TEST 2202. PERFORMANCE OF COMMERCIAL HYBRIDS UNDER BChV INOCULATION, SALINAS, CA, 2002

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Loss[1] %	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Powdery Mildew Score	Virus Yellows 6/26	Virus Yellows 8/5	Virus Yellows 8/29	Virus Yellows Mean
USDA Experimental hybrids (cont.)												
Y190H50	C790-15CMS x RZM Y090	16999	8.49	51.78	16.41	137	84.8	4.5	1.3	3.3	4.1	2.9
Y190H2	C831-3HO x RZM Y090	16652	3.71	50.06	16.64	132	85.4	3.9	1.6	3.3	4.8	3.4
Y190H27	C831-4HO x RZM Y090	18088	2.67	54.87	16.48	143	84.2	5.8	1.5	3.0	3.4	2.7
Beta 6600	rec'd 7-11-00	14597	21.05	38.29	19.05	162	87.9	6.1	4.3	6.3	7.3	5.9
Mean		15296.0		45.98	16.65	150.4	85.0	4.9	3.1	4.7	5.6	4.6
LSD (.05)		1245.6		3.02	0.66	12.5	1.8	0.7	0.6	0.6	0.6	0.4
C.V. (%)		8.3		6.67	4.00	8.4	2.1	13.9	17.7	12.3	11.3	8.5
F value		12.3**		18.75**	15.80**	12.0**	3.5**	26.1**	43.0**	37.8**	30.9	74.9**

[1]Test 2202 and Test 2602 are companion tests. Test 2202 was inoculated May 9, 2002 with *Beet chlorosis virus* (BChV). % loss is the relative sugar yield loss calculated from the corresponding means in each test.

Notes: Virus yellows foliar symptoms were scored on a scale of 0 to 9, where 9 = 90-100% of the mature leaf area yellowed. Scores were made on 6/26, 7/18, 8/05, and 8/29 by JAO.

Powdery mildew was scored on a scale of 0 to 9, where 9 = 90-100% of mature leaf area covered with mildew. PM was controlled until late in the season so PM should have had relatively little effect.

Test 2102 thru 2802 were grown on soil that had been fumigated with methyl bromide in 2000 prior to strawberries in 2001. There appeared to be minimal soil borne problems including no observed rhizomania or sugarbeet cyst nematode. Foliar diseases of rust and downy mildew were minor to moderate. Aphids and worms were controlled as needed with Lorsban and herbicide treatment of Nortron/Betamix was applied once following thinning.

Beet chlorosis virus is one of the components of VY in California and also is known to occur in other beet producing states and in Europe. For several years in the late 1990's, BChV caused significant losses in certain fields in the Northern Great Plains. Varieties listed as Colorado commercial hybrids were chosen because they were grown in the 1990s when BChV was severe or because they represent currently grown hybrids. Beta 6600 was included as a high %S, VY susceptible check.

A83

(cont.)

Variety	Description	Acre Yield				Beets/100' RJAP		Powdery Mildew		Virus Yellows			
		Sugar Lbs	Loss[1] %	Beets Tons	Sucrose %	No.	%	Score	%	6/26 Score	8/5 %	8/29	Mean

Coefficients of Correlation: Partial sets of coefficients of correlation (r), n = 24 were run within the VY inoculated test. These comparisons were chosen to determine the relationship or association between measures of VY (VY scores for individual dates and for the mean VY score) and performance factors and between VY scores and relative % sugar yield loss. There were fair to good associations between VY score and sugar yield but there were good correlations between VY score and relative % sugar yield loss. These results suggest that scoring entries for VY (*Beet Chlorosis Virus*) is predictive of their reaction to VY.

Correlations within VY inoculated test 2202

	SY	RY	%S	RJAP	%loss
VY mean	-.76**	-.76**	.02NS	.43*	.86**
VY 8/29	-.72**	-.76**	.09NS	.47*	.82**
VY 8/05	-.75**				.85**
VY 7/18	-.78**				.86**
VY 6/26	-.71**				.85**
% sugar	.25NS				

Correlations between corresponding test

Non-inoculated test (Test 2602)

VY Inoc.	SY	%S	VY mean	VY 8/29	VY 7/18
SY	.16NS				
%S		.92**			
VY mean			.81**		
VY 8/29				.87**	
VY 7/18					.76**

Correlations were also run between the entry means for corresponding VY inoculated and noninoculated tests. There was a very poor association between these tests for sugar yield, but a high association for %S, and high correlations between VY scores on the same dates. This suggests that the milder and later natural VY (BChV/BWYV) infection in the non-inoculated test could also be used to predict VY reaction of these entries.

TEST 2302. PERFORMANCE OF EXPERIMENTAL HYBRIDS UNDER BChV INOCULATION, SALINAS, CA, 2002

24 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: February 27, 2002
Harvested: October 16, 2002

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Loss[1] %	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Powdery Mildew Score	Virus Yellows 6/26	Virus Yellows 8/5	Virus Yellows 8/29	Virus Yellows Mean
Commercial checks												
Beta 4776R	rec'd 8-31-01	17028	10.89	50.02	17.01	152	85.4	3.0	4.4	5.3	6.5	5.3
HH141	rec'd 8-16-01	14936	24.52	46.26	16.08	162	86.7	5.5	5.0	5.8	7.1	5.9
Phoenix	rec'd 8-16-01	15359	25.51	48.32	15.88	157	86.7	5.9	4.3	5.0	6.6	5.2
Beta 4430R	rec'd 8-31-01	13999	29.93	46.05	15.19	158	85.6	4.8	5.0	6.8	7.8	6.5
Susceptible check												
Crystal 205	2-22-02 (Lot 0205 C8602)	13941	26.48	42.28	16.50	164	84.9	5.8	4.6	6.3	7.6	6.1
Resistant checks												
R176-89-H50	C790-15CMS x RZM R076-89	17370	4.22	54.02	16.06	160	84.9	4.5	3.1	1.9	2.8	4.6
Y169H50	C790-15CMS x RZM-ER-% Y969,(C69)	18365	6.91	55.40	16.56	151	84.3	4.1	3.1	1.9	2.9	4.1
Y190H50	C790-15CMS x RZM Y090	17322	8.19	51.62	16.79	159	84.6	5.0	3.0	1.5	3.0	4.4
MM,S[f],Aa populations												
1931H50	C790-15CMS x RZM 0931,(popn-931)	17829	4.86	53.61	16.65	151	84.9	4.1	3.5	2.0	3.5	5.0
1941H50	C790-15CMS x RZM 0941,(popn-941)	17883	7.43	54.62	16.39	144	85.1	4.0	3.2	1.9	3.3	4.5
Hybrids with S[1] pollinators												
0931-19H50	C790-15CMS x 8930-19,(C930-19)	17962	6.50	53.81	16.70	160	85.5	2.9	3.4	2.4	3.1	4.9
1927-4H50	C790-15CMS x RZM 9927-4,(C927-4)	17423	13.66	53.64	16.24	147	85.0	5.5	3.3	1.8	3.1	5.3
1929-62H50	C790-15CMS x RZM 9929-62,(C929-62)	17890	7.57	54.93	16.30	155	85.0	3.8	3.1	2.0	2.8	4.4
1930-35H50	C790-15CMS x RZM 9930-35,(C930-35)	17403	7.84	49.80	17.46	165	85.4	4.4	4.0	2.5	4.0	5.1

A85

TEST 2302.   PERFORMANCE OF EXPERIMENTAL HYBRIDS UNDER BChV INOCULATION, SALINAS, CA, 2002

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Loss[1] %	Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Powdery Mildew Score	Virus Yellows 6/26	Virus Yellows 8/5	Virus Yellows 8/29	Virus Yellows Mean
Hybrids with S₁ pollinators (cont.)												
1929-4H50	C790-15CMS x RZM 9929-4	18627	4.77	51.80	18.00	146	84.9	3.8	3.7	2.8	3.6	4.9
1924-2H50	C790-15CMS x RZM 9924-2	17849	2.91	52.72	16.99	156	85.7	3.3	2.6	1.4	2.3	3.8
Hybrids with FS pollinators												
Y168-16H50	C790-15CMS x Y968-16	18953	4.65	54.07	17.51	154	86.5	3.6	4.0	3.4	3.6	5.3
R181-22H50	C790-15CMS x R981-22	20360	-1.34	59.81	17.01	144	85.7	3.9	3.1	1.5	3.1	4.6
R178-6H50	C790-15CMS x R978-6	18118	14.25	54.27	16.67	157	85.5	5.4	4.5	3.4	4.4	5.9
R180-11H50	C790-15CMS x R980-11	16936	13.96	50.03	16.91	157	85.4	5.5	4.3	3.3	4.4	5.8
R176-89-5-4H50	C790-15CMS x R976-89-5-4	19385	5.54	57.31	16.86	150	87.0	4.9	2.9	1.6	2.6	4.4
Y167-5H50	C790-15CMS x Y967-5	17458	13.87	53.86	16.17	157	85.5	4.9	3.4	2.3	3.1	5.0
Y172-1H50	C790-15CMS x Y972-1	18213	7.93	53.21	17.10	150	85.1	5.6	3.7	2.4	3.6	5.3
Y175-13H50	C790-15CMS x Y975-13	16388	10.43	51.30	15.93	155	83.3	4.8	3.3	1.8	3.4	4.8
Mean		17374.9		52.20	16.62	154.6	85.4	4.5	2.7	3.8	5.3	3.9
LSD (.05)		1322.8		2.88	0.76	13.3	1.8	0.9	0.6	0.6	0.6	0.4
C.V. (%)		7.7		5.60	4.65	8.7	2.1	19.3	20.6	16.9	10.	9.7
F value		10.6**		13.52**	4.94**		1.5NS	1.7NS	36.9**	27.5**	30.0**	65.4**

[1]Test 2302 and Test 2702 are companion tests. Test 2302 was inoculated May 9, 2002 with *Beet chlorosis virus* (BChV). % loss is the relative sugar yield loss calculated from the corresponding means in each test.

Notes: Virus yellows foliar symptoms were scored on a scale of 0 to 9, where 9 = 90-100% of the mature leaf area yellowed. Scores were made on 6/26, 7/18, 8/05, and 8/29 by JAO.

Powdery mildew was scored on a scale of 0 to 9, where 9 = 90-100% of mature leaf area covered with mildew. PM was controlled until late in the season so PM should have had relatively little effect.

A86

TEST 2302. PERFORMANCE OF EXPERIMENTAL HYBRIDS UNDER BChv INOCULATION, SALINAS, CA, 2002

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Loss[1] %	Beets Tons	Beets/100' Sucrose %	RJAP No.	Powdery Mildew Score	Virus Yellows 6/26	8/5	8/29	Mean

Test 2102 thru 2802 were grown on soil that had been fumigated with methyl bromide in 2000 prior to strawberries in 2001. There appeared to be minimal soil borne problems including no observed rhizomania or sugarbeet cyst nematode. Foliar diseases of rust and downy mildew were minor to moderate. Aphids and worms were controlled as needed with Lorsban and herbicide treatment of Nortron/Pyramin was applied once following thinning.

Coefficients of Correlation: Partial sets of coefficients of correlation (r), n = 24 were run within the VY inoculated test. These comparisons were chosen to determine the relationship or association between measures of VY (VY scores for individual dates and for the mean VY score) and performance factors and between VY scores and relative % sugar yield loss. There were fair to good associations between VY score and sugar yield but there were good correlations between VY score and relative % sugar yield loss. These results suggest that scoring entries for VY (Beet Chlorosis Virus) is predictive of their reaction to VY.

Correlations within VY inoculated test 2302

	SY	RY	%S	RJAP	%loss
VY mean	-.78**	-.82**	-.32NS	.28NS	.86***
VY 8/29	-.79**	-.81**	-.38NS	.27NS	.89***
VY 8/05	-.79**				.86***
VY 7/18	-.78**				.83***
VY 6/26	-.72**				.81**
% sugar	.63NS				

Correlations between corresponding test
Non-inoculated test (Test 2702)

VY Inoc.	SY	%S	VY mean	VY 8/29	VY 7/18
SY	.13NS				
%S		.39NS			
VY mean			.89**		
VY 8/29				.90**	
VY 7/18					.81**

Correlations were also run between the entry means for corresponding VY inoculated and noninoculated tests. There was a very poor association between these tests for sugar yield and %S, but high correlations between VY scores on the same dates. This suggests that the milder and later natural VY (BChV/BWYV) infection in the non-inoculated test could also be used to predict VY reaction of these entries.

A87

TEST 7602. EVALUATION OF TOPCROSS HYBRIDS WITH POPN-931 UNDER RHIZOMANIA, SALINAS, CA, 2002

12 entries x 8 reps., RCB
1-row plots, 22 ft. long

Planted: April 19, 2002
Harvested: October 18, 2002

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Root Rot %	Powdery Mildew Mean
Checks								
Beta 4776R	rec'd 8-31-01	12476	36.86	16.90	177	89.2	6.8	1.9
Angelina	rec'd 3-19-02	13552	39.82	17.01	178	87.1	8.1	6.4
Topcrosses to popn-931								
1931H50	C790-15CMS x RZM 0931	11794	37.59	15.70	153	86.4	9.0	3.4
1931H5	0833-5HO x RZM 0931	11962	36.38	16.45	119	87.0	1.8	3.9
1931H6	0833-5H50 x RZM 0931	12403	38.35	16.19	152	87.2	7.8	3.1
1931H2	9831-3HO x RZM 0931	11916	37.24	16.02	136	86.7	4.7	3.9
1931H27	9831-4HO x RZM 0931	11689	36.71	15.94	144	86.2	6.0	4.1
1931H29	0831-4-10HO x RZM 0931	12060	38.39	15.69	134	86.2	6.3	4.9
1931H62	0836-1H5 x RZM 0931	11831	37.24	15.93	141	85.4	4.7	3.9
1931H63	0836-7H5 x RZM 0931	12133	37.88	16.01	136	86.7	12.4	2.1
1931H64	0834-2H5 x RZM 0931	11743	35.63	16.49	151	85.5	7.3	4.6
1931H67	0837-6H5 x RZM 0931	12205	36.75	16.60	138	85.9	9.2	3.4
Mean		12146.9	37.40	16.24	146.6	86.6	7.0	3.8
LSD (.05)		1062.9	2.81	0.62	18.1	1.5	6.1	0.8
C.V. (%)		8.8	7.55	3.84	12.4	1.8	87.3	21.2
F value		1.8NS	1.22NS	4.03**	7.1**	3.3**	1.6NS	18.0**

Notes: See Test 2902 without rhizomania.

A88

TEST 7702. EVALUATION OF TOPCROSS HYBRIDS WITH Y90 UNDER RHIZOMANIA, SALINAS, CA, 2002

24 entries x 8 reps., RCB(e)
1-row plots, 18 ft. long

Planted: April 19, 2002
Harvested: October 18, 2002

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Root Rot %	Powdery Mildew Mean
Checks								
Beta 4430R	rec'd 8-31-01	12197	35.69	17.09	162	87.8	0.8	3.3
Phoenix	rec'd 8-16-01	10885	32.39	16.79	162	87.6	3.5	5.0
Topcrosses to Y90								
Y190H50	C790-15CMS x Y090	11608	34.49	16.82	136	86.0	7.2	4.0
Y190H5	C833-5HO x Y090	10796	31.46	17.11	93	85.1	1.9	3.8
Y190H6	C833-5H50 x Y090	12082	35.04	17.27	119	87.1	2.3	4.5
Y190H45	C867-1HO x Y090	11180	33.54	16.66	114	86.2	1.4	3.8
Y190H2	C831-3HO x Y090	11641	34.19	16.99	111	86.8	3.9	4.8
Y190H27	C831-4HO x Y090	11798	35.64	16.59	112	83.9	1.5	4.5
Y190H27	C833-5aa x Y090	11349	31.96	17.77	117	85.9	1.0	3.9
Y190H29	0831-4-10HO x Y090	12724	38.69	16.40	138	84.9	1.3	4.4
Y190H62	0836-1H5 x Y090	11853	34.14	17.36	106	86.5	3.6	3.5
Y190H63	0836-7H5 x Y090	12336	36.61	16.88	124	86.1	6.8	2.6
Y190H64	0834-2H5 x Y090	11176	34.56	16.24	115	86.1	2.5	4.8
Y190H67	0837-6H5 x Y090	11305	32.81	17.25	123	85.8	0.4	4.9
Y190H82	C833-5H2 x Y090	11656	34.43	16.91	111	85.5	1.6	4.3
Y190H83	C833-5H27 x Y090	11732	34.60	16.95	127	86.6	1.6	4.0
Y190H84	C833-5H45 x Y090	11114	32.79	16.95	122	84.6	8.0	4.4
Y190H85	C833-5H46 x Y090	12274	35.65	17.21	143	86.7	2.2	5.0
Y190H3	97-C562HO x Y090	10582	31.14	16.99	135	85.4	4.1	4.5
Y190H46	9869-6HO x Y090	11727	35.18	16.66	130	86.0	4.8	5.3

TEST 7702. EVALUATION OF TOPCROSS HYBRIDS WITH Y90 UNDER RHIZOMANIA, SALINAS, CA, 2002

(cont.)

| Variety | Description | Acre Yield | | Sucrose | Beets/100' | RJAP | Root Rot | Powdery Mildew |
		Sugar Lbs	Beets Tons	%	No.	%	%	Mean
Y190H55	0835HO x Y090	11520	34.95	16.48	144	85.5	3.1	4.0
Y190H56	0836HO x Y090	11523	34.58	16.65	139	85.1	7.6	4.9
Y190H70	9869HO x Y090	12047	34.54	17.42	152	86.3	7.5	4.9
Y190H51	0841HO x Y090	11680	34.28	17.08	152	86.7	4.4	4.3
Mean		11616.1	34.31	16.94	128.7	86.0	3.5	4.3
LSD (.05)		1047.7	3.05	0.55	16.2	2.0	6.2	0.8
C.V. (%)		9.2	9.02	3.30	12.8	2.3	182.7	17.9
F value		1.9*	2.35**	3.19**	9.6**	1.7NS	1.2NS	5.3**

Notes: See Test 3002 without rhizomania.

Descriptions:
HO = CMS; H5 = C833-5CMS x T-O; H27 = C831-4CMS x T-O; H45 = C867-1CMS x T-O; H46 = 9869-6HO x T-O.
Y090 = Cycle 1,Syn 1 from FS selection of MM,O.P. lines.

A90

TEST 7802. EVALUATION OF HYBRIDS WITH SELF-STERILE POLLINATORS UNDER RHIZOMANIA, SALINAS, CA, 2002

48 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: April 22, 2002
Harvested: November 4, 2002

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Root Rot %	Powdery Mildew Mean
Checks								
Beta 4776R	rec'd 8-31-01	12390	32.85	18.85	161	88.5	0.7	2.9
Beta 4430R	rec'd 8-31-01	13475	36.56	18.43	173	89.1	1.8	4.6
Phoenix	rec'd 8-16-01	11209	30.80	18.19	157	89.1	2.1	6.5
HH 141	rec'd 8-16-01	11384	30.46	18.69	155	87.8	0.4	6.6
Hybrids with FS lines								
R178H50	C790-15CMS x RZM-ER-% R978	11031	30.79	17.90	158	87.0	1.4	5.5
R178-5H50	x R978-5	10581	29.22	18.10	168	87.7	1.4	4.9
R178-6H50	x R978-6	12097	33.26	18.19	161	87.6	1.4	5.1
R178-11H50	x R978-11	12030	32.50	18.51	170	88.2	2.4	5.8
Y169H50	C790-15CMS x RZM-ER-% Y969	11484	31.54	18.21	160	87.7	1.1	5.1
Y168-8H50	x Y968-8	12067	32.59	18.51	157	87.9	3.2	4.5
Y168-13H50	x Y968-13	10196	27.52	18.54	150	88.6	2.3	4.4
Y168-16H50	x Y968-16	11663	31.62	18.45	155	87.2	1.5	4.3
R180H50	C790-15CMS x RZM-ER-% R980	11829	32.35	18.26	151	86.9	2.3	5.3
R180-11H50	x R980-11	12138	33.00	18.39	157	86.4	3.7	5.6
R180-16H50	x R980-16	11740	31.88	18.40	161	87.7	1.5	5.9
R180-21H50	x R980-21	12195	32.80	18.60	166	86.2	1.0	5.4
Mean		11719.3	31.86	18.39	160.0	87.7	1.8	5.1
LSD (.05)		878.7	2.37	0.46	10.6	1.6	3.4	0.6
C.V. (%)		7.6	7.51	2.54	6.7	1.9	193.8	10.7
F value		6.0**	5.46**	2.09*	3.2**	2.2*	0.5NS	22.3**

TEST 7802. EVALUATION OF HYBRIDS WITH SELF-STERILE POLLINATORS UNDER RHIZOMANIA, SALINAS, CA, 2002
48 entries x 8 reps., RCB(e). ANOVA across tests to compare means.

		Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Root Rot %	Powdery Mildew Mean
Mean		11969.0	32.62	18.34	160.9	87.4	1.8	5.2
LSD (.05)		992.5	2.47	0.50	12.0	1.7	3.6	0.6
C.V. (%)		8.4	7.69	2.79	7.6	2.0	209.6	11.3
F value		5.0**	4.88**	4.67**	4.9**	2.0**	0.8NS	19.2**

TEST 7802. EVALUATION OF HYBRIDS WITH SELF-STERILE POLLINATORS UNDER RHIZOMANIA, SALINAS, CA, 2002

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Root Rot %	Powdery Mildew Mean
Test 02-2: 16V x 8R, RCB								
R176-89H50	C790-15CMS x R076-89	11208	31.43	17.84	140	88.0	0.8	5.4
R176-89-5H50	x RZM R076-89-5	11539	31.43	18.38	161	88.6	0.4	5.1
R176-89-5-4-H50	x R976-89-5-4	11838	31.38	18.86	163	86.8	2.2	5.1
R176-89-5NB-4H50	x R976-89-5NB-4	11984	32.00	18.70	159	88.2	2.5	4.5
R176-89-5-13H50	x R976-89-5-13	10688	28.81	18.52	162	86.9	2.2	6.0
R181-22H50	x R981-22	12357	33.21	18.61	165	88.5	2.7	4.5
Y167H50	x RZM-ER-% Y967	12205	33.09	18.45	156	87.0	1.1	5.3
Y167-5H50	x R978-5	12188	33.54	18.17	171	87.1	2.6	4.1
Y171H50	C790-15CMS x RZM-ER-% Y971	11641	32.44	17.94	157	87.0	0.4	6.5
Y172-1H50	x Y972-1	13097	34.92	18.76	172	86.3	0.9	5.8
Y172-5H50	x Y972-5	11988	33.06	18.14	168	87.7	2.5	5.1
Y172-7H50	x Y972-7	12262	33.86	18.11	172	87.0	1.3	5.8
Y175H50	C790-15CMS x Y075	11556	32.81	17.58	159	87.0	3.5	5.0
Y175-13H50	x Y975-13	12517	33.99	18.44	164	87.9	0.8	5.0
Y190H50	x Y090	10977	30.19	18.17	136	88.0	0.5	5.3
R170H50	x RZM-ER-% R970	11484	31.49	18.23	160	87.0	0.7	5.1
Mean		11845.6	32.35	18.31	160.3	87.5	1.6	5.2
LSD (.05)		945.1	2.33	0.53	11.7	1.6	3.3	0.5
C.V. (%)		8.1	7.28	2.94	7.4	1.9	213.8	9.9
F value		3.3**	3.42**	3.43**	5.8**	1.4NS	0.7NS	10.4**

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Root Rot %	Powdery Mildew Mean
Test 03: 16V x 8R, RCB								
P129H50	C790-15CMS x PMR-RZM P029-#(C)	12478	33.43	18.65	162	87.7	4.1	5.1
P130H50	x PMR-RZM P030-#(C)	12278	33.18	18.51	164	86.8	3.6	4.9
P118-6H50	x P918-6	12299	33.94	18.10	166	85.3	3.5	5.5
R021H50	x RZM R926,R927,(C26,C27)	10951	30.88	17.73	141	87.8	4.2	5.8
P007/8H50	x PMR-RZM P807,P808	12734	34.64	18.36	166	87.6	3.4	4.3
R143H50	x RZM-ER-% R943	13505	36.81	18.35	159	86.5	0.9	4.9
R140H50	x RZM-ER-% R940,R954	12312	33.85	18.20	168	87.2	0.0	5.0
R136H50	x RZM-ER-% R936	12351	34.98	17.64	167	86.4	2.0	6.3
Retests from 2000 seed								
R078-4H50	C790-15CMS x R878-4	12049	33.41	18.06	171	88.2	0.0	5.4
Y067-3H50	x Y867-3	11003	31.23	17.63	131	87.1	1.4	4.8
Y069-18H50	x Y869-18	10817	29.73	18.16	154	87.6	2.6	4.3
R080/2-9H50	C790-15CMS x R880/2-9	12298	32.11	19.15	161	86.0	1.4	5.5
R080/2-11H50	x R880/2-11	12106	33.45	18.10	170	86.6	0.3	5.1
Y072-4H50	x Y872-4	12696	34.39	18.48	166	86.5	0.6	5.3
Checks								
Angelina	rec'd 3/19/02	13838	35.07	19.75	174	89.4	0.4	8.8
Beta 4001R	rec'd 9/25/01	13762	37.08	18.49	176	86.7	2.5	3.1
Mean		12342.2	33.64	18.33	162.3	87.1	1.9	5.2
LSD (.05)		1077.6	2.59	0.48	10.8	1.9	4.2	0.5
C.V. (%)		8.8	7.77	2.67	6.7	2.2	217.3	10.1
F value		5.5**	4.58**	9.91**	9.3**	2.0*	1.0NS	39.9**

A93

TEST 7902. EVALUATION OF HYBRIDS WITH S_1 PROGENY LINE POLLINATORS UNDER RHIZOMANIA, SALINAS, CA, 2002

48 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: April 22, 2002
Harvested: April 22, 2002

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Root Rot %	Bolting %	Powdery Mildew Mean
Test 02-1: 16V x 8R, RCB									
Checks									
HH 141	rec'd 8-16-01	11771	32.09	18.36	140	86.9	0.8	0.0	5.8
Phoenix	rec'd 8-16-01	13309	36.35	18.31	162	88.4	1.0	0.0	5.6
Beta 4776R	rec'd 8-31-01	14432	38.80	18.61	159	87.4	0.0	0.0	2.3
Beta 4430R	rec'd 8-31-01	14961	40.19	18.64	173	87.9	0.3	0.0	3.9
Retests & new seed productions									
CR009-1H50	C790-15CMS x CR909-1	13209	37.03	17.84	156	85.3	0.0	0.7	4.9
Z025-9H50	x Z825-9	13712	34.91	19.66	160	86.9	0.0	0.0	3.3
0930-19H50	x 8930-19	13486	37.35	18.06	161	88.2	0.8	0.0	4.1
1930-19H50	x NB 8930-19	13213	36.49	18.11	149	86.7	0.0	0.0	3.8
1927-4H50	C790-15CMS x RZM 9927-4	14774	41.37	17.85	130	87.2	5.0	0.0	5.4
1929-62H50	x RZM 9929-62	13424	38.15	17.60	131	87.1	1.6	0.4	4.1
1930-35H50	x RZM 9930-35	13243	35.10	18.86	137	86.0	0.4	0.0	4.8
1929-4H50	x RZM 9929-4	13013	34.97	18.61	152	86.4	0.9	0.0	4.6
1924-2H50	x RZM 9924-2	12738	35.15	18.13	138	87.1	0.0	0.0	4.5
0936-10H50	x 8936-10	15212	40.46	18.80	153	87.2	1.5	0.0	4.5
0936-16H50	x 8936-16	12373	32.40	19.11	161	85.8	1.0	0.0	3.6
1924H50	x RZM-ER-% 9924	13910	39.21	17.74	149	88.2	2.6	0.0	4.4
Mean		13548.7	36.88	18.39	150.7	87.0	1.0	0.1	4.3
LSD (.05)		928.5	2.33	0.54	13.6	2.1	4.1	0.4	0.6
C.V. (%)		6.9	6.38	2.94	9.1	2.4	415.4	638.5	12.9
F value		7.9**	10.79**	8.37**	6.5**	1.4NS	0.8NS	1.6NS	20.5**

TEST 7902. EVALUATION OF HYBRIDS WITH S_1 PROGENY LINE POLLINATORS UNDER RHIZOMANIA, SALINAS, CA, 2002
48 entries x 8 reps., RCB(e). ANOVA across tests to compare means.

		Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Root Rot %	Bolting %	Powdery Mildew Mean
Mean		13480.6	36.82	18.32	146.8	87.1	1.4	0.2	4.6
LSD (.05)		1011.5	2.65	0.56	14.9	2.1	3.8	0.9	0.6
C.V. (%)		7.6	7.30	3.10	10.3	2.4	273.6	382.8	13.4
F value		7.3**	7.32**	7.89**	9.7**	1.5*	1.0NS	8.8**	22.3**

TEST 7902. EVALUATION OF HYBRIDS WITH S_1 PROGENY LINE POLLINATORS UNDER RHIZOMANIA, SALINAS, CA, 2002

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Root Rot %	Bolting %	Powdery Mildew Mean
Test 02-2: 16V x 8R, RCB									
Checks									
Angelina	rec'd 3-19-02	14929	38.96	19.16	176	89.1	0.9	0.0	8.5
Beta 4001R	rec'd 9-25-01	15518	41.02	18.94	180	88.2	0.6	0.0	2.1
1931H50(Sp)	C790-15CMS x 9931(C)	14679	41.02	17.89	148	88.8	1.5	0.0	4.8
1941H50(Sp)	x 9941(C)	13001	36.80	17.67	136	86.3	4.6	0.0	4.6
Selected S_1 lines									
1931-56H50	C790-15CMS x 9931-56	14333	39.73	18.01	159	87.4	3.2	0.0	2.9
1931-201H50	x 9931-201	13940	39.48	17.65	169	88.4	4.8	0.0	3.4
1935-6H50	x 9935-6	12151	32.85	18.48	159	87.6	3.2	0.0	4.5
1936-14H50	x 9936-14	13650	37.89	18.02	158	86.5	1.0	0.0	3.4
Check									
Z125H50	C790-15CMS x Z025(C)	11225	31.71	17.71	129	86.8	2.2	0.0	4.5
Selected S_1 lines									
Z131-14H50	C790-15CMS x Z931-14	13937	36.88	18.90	156	87.6	1.9	0.0	5.0
Z131-18H50	x Z931-18	13531	36.58	18.48	156	87.2	1.7	0.0	4.4
1942H50	x RZM 0942	12677	36.08	17.61	132	86.0	0.0	0.0	4.4
Check									
CR111H50	C790-15CMS x CR11(C)	13131	37.49	17.52	137	87.3	1.3	0.0	5.1
Selected S_1 lines									
CR110-14-2H50	C790-15CMS x CR910-14-2	12655	35.34	17.92	163	87.6	0.6	3.9	6.8
CR110-5H50	x CR910-5	13030	35.49	18.34	168	86.7	1.6	0.0	4.6
CR112-5H50	x CR812-5	14387	39.71	18.15	156	88.3	3.2	0.0	5.5
Mean		13548.3	37.31	18.15	155.1	87.5	2.0	0.2	4.7
LSD (.05)		1098.7	2.95	0.54	12.9	1.8	4.0	0.9	0.6
C.V. (%)		8.2	7.99	3.00	8.4	2.1	199.9	390.3	13.5
F value		8.0**	6.47**	7.12**	10.7**	1.9*	1.0NS	8.4**	45.5**

A95

TEST 7902. EVALUATION OF HYBRIDS WITH S₁ PROGENY LINE POLLINATORS UNDER RHIZOMANIA, SALINAS, CA, 2002

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Root Rot %	Bolting %	Powdery Mildew Mean
Test 02-3: 16V x 8R, RCB									
Population hybrids									
1932H50 C790-15CMS	x RZM-ER-% 9932	12259	34.71	17.66	111	87.5	2.5	0.0	4.9
1933H50	x RZM-ER-% 9933	13058	36.33	17.99	160	87.6	2.5	5.1	5.1
N124H50	x NR-RZM N024	14096	39.26	17.99	164	88.2	1.3	0.0	5.0
01-FC1030H50	x FC1030(C)	11365	33.26	17.09	144	87.1	1.7	0.0	5.1
Testcross hybrids to C833-5CMS									
1931H5 0833-5HO	x 0931	13663	37.38	18.29	123	87.8	0.8	0.0	4.9
1941H5	x 0941	12704	34.71	18.33	120	86.6	0.5	0.6	4.8
1942H5	x RZM 0942	13075	35.12	18.61	136	86.0	0.0	0.0	4.5
01-FC1030H5	x FC1030(C)	12548	33.69	18.64	137	87.2	0.0	0.4	5.5
CR111H5	x CR11(C)	13326	36.64	18.19	118	87.4	0.0	0.0	4.9
Z125H5	x Z025(C)	13068	34.77	18.83	118	86.3	0.0	0.0	4.8
0930-19H5 9833-5HO	x 8930-19	14062	37.29	18.86	158	87.0	0.0	0.0	4.3
1930-35H5 0833-5HO	x RZM 9930-35	12650	32.93	19.25	132	85.7	4.5	0.0	5.0
1927-4H5	x RZM 9927-4	14868	41.20	18.04	136	85.5	0.7	0.0	5.6
1929-62H5	x RZM 9929-62	14589	39.31	18.56	132	87.7	0.4	0.0	4.4
1929-4H5	x RZM 9929-4	14082	36.06	19.61	135	86.0	1.6	0.0	4.0
1924-2H5	x RZM 9924-2	14106	37.55	18.80	131	86.4	2.3	0.0	5.1
Mean		13344.9	36.3	18.42	134.7	86.9	1.2	0.4	4.9
LSD (.05)		909.7	2.5	0.59	14.5	2.2	3.0	1.1	0.6
C.V.(%)		6.9	6.8	3.25	10.9	2.6	256.9	286.9	11.7
F value		8.2**	7.1**	8.43**	9.1**	1.1NS	1.4NS	11.0**	4.6**

TEST 8002. RETEST UNDER RHIZOMANIA OF S_1mmaa x C78 TOPCROSSES FROM 2000, SALINAS, CA, 2002

12 entries x 8 reps., RCB
1-row plots, 22 ft. long

Planted: April 22, 2002
Harvested: October 29, 2002

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Root Rot %	Powdery Mildew Mean
Checks								
Beta 4776R	rec'd 8-31-01	14935	40.92	18.29	168	85.5	0.0	1.3
R078H50	C790-15CMS x R978	15691	44.60	17.60	162	85.5	1.4	3.4
R078H5	9833-5(T-O)HO x R978	15319	41.63	18.40	151	84.3	0.0	2.5
Retest of S_1mm lines								
R078H10-17	9810-17aa x R978	14204	40.91	17.36	144	83.7	0.8	3.1
R078H10-19	9810-19aa x R978	14040	39.90	17.60	128	84.7	0.4	3.8
R078H48-1	9848-1aa x R978	14718	42.19	17.45	148	82.5	0.0	4.9
R078H69-9	9869-9aa x R978	14001	40.10	17.45	160	84.1	2.0	3.6
R078H35-8	9835-8aa x R978	14715	40.78	18.05	135	84.5	1.2	4.5
R078H35-10	9835-10aa x R978	14308	39.55	18.09	117	84.7	0.6	3.1
R078H35-24	9835-24aa x R978	14652	42.11	17.41	126	83.4	0.5	3.4
R078H36-4	9836-4aa x R978	12183	36.07	16.95	39	85.0	0.0	2.0
R078H36-13	9836-13aa x R978	15149	43.13	17.58	114	83.0	1.4	2.4
Mean		14493.0	40.99	17.69	132.8	84.2	0.7	3.2
LSD (.05)		1201.5	3.57	0.61	18.2	1.4	1.8	0.9
C.V. (%)		8.3	8.74	3.48	13.7	1.7	262.3	28.8
F value		4.4**	2.78**	3.89**	28.5**	3.4**	1.1NS	10.1**

TEST 8102. EVALUATION UNDER RHIZOMANIA OF TESTCROSS HYBRIDS TO C833-5CMS, SALINAS, CA, 2002

Planted: April 22, 2002
Harvested: October 31, 2002

24 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Root Rot %	Powdery Mildew Mean
Checks								
Phoenix	rec'd 8-16-01	13682	37.13	18.48	166	86.8	1.1	3.6
Beta 4776R	rec'd 8-31-01	14827	38.00	19.56	170	86.4	0.0	0.8
Beta 4430R	rec'd 8-31-01	14732	39.71	18.61	172	85.6	0.0	1.6
HH141	rec'd 8-16-01	12887	35.30	18.29	172	84.8	0.0	2.6
Testcrosses with lines & populations								
R078H5	9833-5(T-O)HO x R978	14136	37.47	18.88	164	83.2	1.5	2.9
Y190H5	0833-5HO x RZM Y090	13567	35.15	19.29	111	84.2	0.0	2.9
Y175H5	0833-5HO x RZM Y075	13496	36.50	18.51	153	82.9	1.3	1.9
R176-89H5	" " x R076-89	13688	36.60	18.73	155	82.8	0.0	1.5
1942H5	" " x RZM 0942	13902	36.54	19.04	170	83.7	0.0	1.9
01-FC1030H5	" " x FC 1030(C)	12555	33.95	18.51	160	82.6	0.0	2.3
1931H5	" " x RZM 0931(C)	14294	38.31	18.66	157	82.7	0.9	2.0
1941H5	" " x RZM 0841(C)	13178	35.09	18.80	159	83.6	0.0	1.9
CR111H5	" " x RZM CR011(C)	14542	39.16	18.60	153	83.9	0.8	2.9
Z125H5	" " x RZM Z025	13933	35.69	19.56	153	84.5	0.0	2.6
Testcrosses with progeny lines								
Z025-9H5	9833-5HO x Z825-9	13652	33.67	20.29	165	84.0	1.0	1.1
CR009-1H5	" " x CR909-1	13971	36.88	18.94	167	83.5	0.3	2.6
0930-19H5	9833-5HO x 8930-19	14422	38.07	18.96	176	83.1	0.7	2.5
0929-112H5	" " x 8929-112	14193	36.94	19.24	170	82.6	0.0	3.8
0929-114H5	" " x 8929-114	13576	35.55	19.20	174	83.0	0.0	1.8
1929-4H5	0833-5HO x RZM 9929-4	13516	34.62	19.54	161	83.0	0.3	2.0

TEST 8102. EVALUATION UNDER RHIZOMANIA OF TESTCROSS HYBRIDS TO C833-5CMS, SALINAS, CA, 2002

(cont.)

Variety	Description	Acre Yield		Sucrose	Beets/100'	RJAP	Root Rot	Powdery Mildew
		Sugar Lbs	Beets Tons	%	No.	%	%	Mean
Testcrosses with progeny lines (cont.)								
1929-62H5	0833-5HO x RZM 9929-62	13823	36.33	19.04	162	83.6	0.6	1.9
1930-35H5	" " x RZM 9930-35	13431	34.37	19.61	164	82.7	0.0	2.1
1924-2H5	" " x RZM 9924-2	13441	34.99	19.23	163	83.7	0.0	1.5
1927-4H5	" " x RZM 9927-4	13724	37.13	18.52	160	82.1	0.0	2.5
Mean		13798.8	36.38	19.00	161.6	83.7	0.4	2.2
LSD (.05)		1070.8	2.92	0.59	12.5	2.0	1.6	1.0
C.V. (%)		7.9	8.14	3.18	7.9	2.5	452.2	45.4
F value		2.0NS	2.33NS	4.99**	8.0**	2.6**	0.8NS	4.1**

TEST 7502-1. WESTERN SUGAR, HOLLY SUGAR (TORRINGTON), MONITOR SUGAR, USDA HYBRID EVALUATION UNDER RHIZOMANIA, SALINAS, CA, 2002

36 entries x 4 reps, RCB
1-row plots, 22 ft. long

Planted: April 19, 2002
Harvested: October 2002

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Stand Count No.	Harv. Count No.	Beets/100' No.	Root Rot %	Powdery Mildew Score	RJAP %	Rhizomania Resistance DI	Rhizomania Resistance %R(0-4)
Checks												
Beta 4776R	resist ck., 2-5-02	12644	36.71	17.21	38	38	172	2.1	2.3	85.6	2.5	99.3
Beta 4430R	resist ck., 8-31-01	12018	34.74	17.31	38	35	172	9.7	3.5	86.7	2.3	100.0
Beta 6600	susc. ck., 2-5-02	9048	24.55	18.42	36	29	164	13.3	5.5	87.2	3.4	75.2
Phoenix	resist ck., 8-16-01	11268	33.45	16.81	36	27	161	10.9	5.3	86.7	2.9	98.4
HH 141	resist ck., 8-16-01	10598	31.03	17.08	34	34	152	1.5	5.5	86.0	2.7	97.9
US H11	susc. ck.	7633	25.30	15.09	35	32	159	12.5	7.0	85.2	3.4	76.6
Rizor	resist ck., 3-29-01	11396	30.94	18.35	39	38	176	1.9	5.8	86.5	3.0	96.6
Monohikari	susc. ck., 4-5-02	9065	27.54	16.50	37	31	169	13.7	6.0	85.9	3.6	70.8
Western Sugar Entries Not In Common With Holly												
(2)Beta 4595R	4-5-02	10497	29.28	17.93	39	39	176	0.0	6.3	84.1	2.9	97.1
(5)SX Kojak	4-5-02	9998	30.22	16.52	39	36	177	8.5	4.5	85.2	3.2	85.7
(9)Beta OJ5423	4-5-02	10654	30.12	17.67	38	34	174	10.3	5.5	85.3	3.0	95.8
(10)Crystal R243	4-5-02	11067	28.96	19.13	38	38	172	3.3	6.8	86.9	3.0	97.9
(11)SX 0224	4-5-02	9741	26.40	18.46	29	35	132	2.2	5.3	86.8	3.5	77.9
(12)SX0225	4-5-02	9823	28.01	17.50	36	33	162	3.8	5.8	86.3	3.2	90.4
(15)Monohikari	4-5-02, susc.ck.	8672	26.72	16.21	37	31	168	13.9	6.3	87.3	3.5	77.0
Coded Holly Entries & those in common with WS entries												
(1)Crystal 9941	4-4-02	11036	30.30	18.21	37	32	168	12.3	5.0	85.7	3.0	95.3
(2)01HX051	4-4-02	10990	30.01	18.30	38	37	172	3.8	5.5	83.9	2.8	95.9
(3)Beta BA1071	4-4-02	11279	30.45	18.52	37	37	168	1.4	5.8	84.5	2.9	97.8
(4)00HX011R	4-4-02	11233	31.35	17.94	38	39	173	8.2	5.5	85.2	2.9	98.7
(5)01HX016	4-4-02	10650	30.19	17.61	38	37	172	2.0	5.3	85.1	3.1	96.5

Entries 16-28 include from WS & HS: (1)Beta 4940R, (3)Crystal 9906, (9941), (6)HM1639Rz, (7)HM1646Rz, (8)Beta BA1071, (13)HM1651Rz, (14)HMlonly from Holly: Beta BA1151, 01HX016, 01HX011R, 00HX011R, 01HX051, 02HX212R.

TEST 7502-1. WESTERN SUGAR, HOLLY SUGAR (TORRINGTON), MONITOR SUGAR, USDA HYBRID
EVALUATION UNDER RHIZOMANIA, SALINAS, CA, 2002

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Stand Count No.	Harv. Count No.	Beets/ 100' No.	Root Rot %	Powdery Mildew Score	RJAP %	Rhizomania Resistance DI	Rhizomania Resistance %R(0-4)
Coded Holly Entries & those in common with WS entries (cont.)												
(6) Beta 4940R	4-4-02	10074	27.30	18.46	39	36	178	7.1	6.0	84.8	3.0	92.8
(7) Beta BA1151	4-4-02	10669	30.11	17.70	39	34	176	11.4	6.0	85.4	3.2	89.8
(8) HM1653Rz	4-4-02	10433	29.52	17.66	40	34	182	13.8	6.3	85.8	2.8	99.1
(9) HM1651Rz	4-4-02	11002	29.14	18.88	38	35	173	4.9	4.8	85.8	2.9	99.2
(10) HM1639	4-4-02	9285	27.36	16.99	37	36	166	4.7	6.0	84.7	3.0	94.8
(11) Crystal 9906	4-4-02	10958	30.38	18.03	38	39	173	3.8	6.8	86.1	2.6	98.8
(12) 02HX212R	4-4-02	9130	24.93	18.32	36	33	161	3.1	6.0	82.0	3.2	90.3
(13) HM1646	4-4-02	10139	26.81	18.89	39	35	177	9.7	3.8	84.3	3.3	86.1
Monitor Sugar												
HM-E17	susc. ck., 3-21-02	8298	24.04	17.26	38	33	172	8.3	5.3	84.9	3.6	71.7
(1) HM 2761Rz	Monitor Sugar, 4-1-02	10299	28.47	18.05	37	30	166	16.0	3.5	84.6	2.9	94.9
(2) HM 2763Rz	Monitor Sugar, 4-1-02	9757	26.65	18.30	41	35	184	7.9	3.8	85.3	2.8	95.7
(3) VDH 46526	Monitor Sugar, 4-1-02	9069	24.84	18.23	38	34	174	12.1	5.3	85.0	3.0	98.3
(4) HM-E17	Monitor Sugar, 4-1-05	9030	25.78	17.52	41	35	185	10.8	5.5	86.1	3.4	80.9
USDA entries												
1927-4H5	C833-5HO x C927-4	12826	38.07	16.84	32	27	144	13.4	5.5	84.1	2.5	99.1
1930-35H5	C833-5HO x C930-35	10332	28.49	18.14	32	28	143	12.8	4.5	83.7	2.7	99.0
1929-62H5	C833-5HO x C929-62	11943	35.68	16.72	33	31	149	5.5	3.5	85.1	2.7	98.2
Mean		10348.7	29.27	17.69	36.9	33.9	167.8	7.8	5.3	85.4	3.0	91.9
LSD (.05)		1277.3	3.39	0.55	4.8	5.9	21.8	11.7	1.0	1.7	0.3	10.1
C.V. (%)		8.8	8.27	2.21	9.2	12.4	9.2	106.7	13.9	1.5	7.4	7.9
F value		6.6**	7.72**	19.29**	2.3**	2.4**	2.3**	1.3NS	8.2**	3.2**	8.1**	6.1**

TEST 7502-1. WESTERN SUGAR, HOLLY SUGAR (TORRINGTON), MONITOR SUGAR, USDA HYBRID
EVALUATION UNDER RHIZOMANIA, SALINAS, CA, 2002

(cont.)

Variety Description	Acre Yield		Sucrose %	Stand Count No.	Harv. Count No.	Beets/ 100' No.	Root Rot %	Powdery Mildew Score	RJAP %	Rhizomania Resistance DI %R(0-4)
	Sugar Lbs	Beets Tons								

NOTES: Because of severity of trials the past two years, this test was planted 2 weeks earlier into cooler soil. After planting, the test was judiciously sprinkler irrigated to get emergence, but not to promote damping-off and root diseases. Combined with the continuous cool conditions in 2002, rhizomania developed lightly and sugarbeets grew well. Based upon border effects, it appeared that by early September most nitrogen had been depleted, but the crop retained a full canopy through to harvest. Other than as noted below, diseases and pests did not appear to be a problem. The plots were hand harvested, individual roots scored for rhizomania, and placed in two sample bags for clean-tared weight and % sugar analyses.

Entries: USH11, Beta 6600, Monohikari, and HM-E17 were grown as susceptible checks. Beta 4776R, Beta 4430R, Phoenix, HH141, and Rizor were grown as resistant checks. C833-5HO = RzmmCMS; C930-35 & C929-62 = RzMM; C927-4 = MM with rhizomania resistance from C51(*Bvm*).

Harvest Count: Number of roots counted and scored at harvest per plot. An average of 136 roots were scored for each entry.

Beets/100'': Number of plants per 100 ft. of row, counted post thinning.

Root Rot %: Frequency of roots with noticeable root rot, most caused by *Scelerotium rolfsii*, the cause of southern rot. Rotted roots were scored 0 to 9, where 9 is most severe. Roots scored for rhizomania when possible, included in gathered beets for weighing, but were discarded prior to running samples through the sugar lab.

Powdery Mildew Score: Mildew was controlled until late in the season. Just prior to harvest, powdery mildew was scored on a scale of 0 to 9, where 9 = 90-100% of leaf area covered. Even though scores were moderately high, powdery mildew would have had little overall influence on sugar yield.

RJAP = raw juice apparent purity.

Rhizomania Scores: All 8 reps were hand harvested and scored. Reps 1-4 on 10/21/02 & reps 5-8 on 10/30/02. After being lifted, the roots were hand shaken to remove soil and laid out. Each individual root was scored on a scale of 0 to 9, where 9 is most severe. Roots scored 0 to 4 were considered resistant and 5 to 9 were susceptible. Most resistant roots were scored as 3's and most susceptible ones as 5's. Following scoring all beets were topped and placed into two sample bags. After washing, the samples were run through the sugar lab.

TEST 7502-1. WESTERN SUGAR, HOLLY SUGAR (TORRINGTON), MONITOR SUGAR, USDA HYBRID
EVALUATION UNDER RHIZOMANIA, SALINAS, CA, 2002

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Stand Count No.	Harv. Count No.	Beets/ 100' No.	Root Rot %	Powdery Mildew Score	RJAP %	Rhizomania Resistance DI %R(0-4)

The reaction to rhizomania was mild in this test. Rhizomania tests with good results were run in this same field plot area 4 years earlier and were adjacent to the 2001 test area. Because of the severity in 2001, precautions were used to decrease the effects of disease. The rhizomania tests were planted 2 weeks earlier into cooler soil and then irrigated carefully to help prevent development of soilborne problems. In addition, the 2002 season was consistently cool. Based upon foliage color (yellowing), rhizomania was a factor but most infection occurred on the lateral roots where scoring is difficult and the tap roots of all plants grew more or less normally.

Coefficients of correlations(r) were individually calculated:

	% Resist	HC	SY	RY	%S
Disease Index	-0.88**	-0.31**	-0.66**	-0.63**	-0.13NS
% Resistant		0.30**	0.57***	0.49***	0.27**
Harvest Count			0.38**	0.29***	0.27**
Sugar Yield				0.95**	0.24**
Root Yield					-0.09NS

Significant correlations occurred between sugar yield and % resistant ($r = .57$) and disease index and sugar yield ($r = -.66$). However, these low relationships in this test mostly show trends. Within sets of varieties with known performance without rhizomania, the relative performance in this test under rhizomania may be useful to characterize resistance. Unfortunately, the susceptible checks did not show high enough levels of disease to be properly scored and determining the true frequency of susceptible plants in the test varieties was not possible.

A103

TEST 7402-2.   RHIZOMANIA CODED VARIETY TESTS, SALINAS, CA, 2002

96 entries x 4 reps, RCB
1-row plots, 22 ft. long

Planted: April 19, 200
Harvested: November 20, 2002

Code No.	Variety	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Stand Count No.	Harv. Count No.	Beets/ 100' No.	Root Rot %	RJAP %	Powdery Mildew Score	Rhizomania Resistance DI	Rhizomania Resistance %R(0-4)	Seg Pat Code
1	02HX247	12372	31.02	19.95	35	36	163	0.0	87.4	5.0	3.2	97.3	1.3
2	02HX221	13444	36.27	18.51	23	23	114	0.0	86.4	6.5	3.3	90.5	1.3
3	01HX004	13961	40.30	17.34	36	35	163	0.7	88.9	5.3	3.0	99.2	1.0
4	Beta 4175R	12988	36.12	18.00	38	38	174	0.0	88.4	5.5	2.8	100.0	1.0
5	99HX981	13878	39.07	17.81	36	37	167	0.0	88.9	4.5	3.2	98.1	1.3
6	02HX204	12395	32.71	18.95	36	35	169	1.4	88.9	5.3	3.3	92.8	1.3
7	02HX220	13838	38.25	18.08	37	35	170	4.4	89.5	6.0	3.1	95.6	1.0
8	02HX207	13745	37.40	18.41	36	36	165	1.3	90.0	5.8	3.2	95.2	1.3
9	02HX201	14368	40.68	17.75	36	35	164	5.2	89.9	5.3	3.3	92.8	1.0
10	0GK7210	12527	32.58	19.24	35	36	160	0.0	87.1	6.0	3.3	91.3	1.3
11	0GK1642	15108	39.78	18.99	40	40	183	0.0	88.6	2.3	3.0	98.7	1.0
12	9GK1705	15409	42.62	18.07	39	39	180	0.7	89.3	4.0	3.2	96.0	1.0
13	Beta 4776R	14173	37.82	18.75	41	42	185	0.0	88.9	2.0	2.9	98.2	1.0
14	9GK1701	15433	42.97	17.96	35	35	159	0.0	88.7	4.3	3.0	97.1	1.0
15	02HX218	12058	30.53	19.75	33	34	149	0.0	86.1	5.0	3.1	97.0	1.0
16	Beta 4440R	13228	36.39	18.16	37	36	169	2.1	90.7	4.5	3.1	97.8	1.0
17	9J0158	12084	31.19	19.36	40	38	182	3.1	87.5	5.3	3.4	89.4	2.0
18	02HX203	13134	37.02	17.77	35	34	159	0.6	87.8	7.0	3.0	99.2	1.0
19	Eagle	13768	37.45	18.40	38	37	174	0.0	89.5	6.5	3.2	98.6	1.0
20	Beta 4035R	12970	35.20	18.44	37	37	166	0.0	87.3	5.8	3.0	98.5	1.3
21	0GK1629	13306	37.08	17.96	38	37	170	0.0	89.3	4.8	3.0	99.4	1.0
22	1GL0062	15679	41.55	18.88	38	37	173	0.0	89.0	3.5	2.7	99.3	1.0
23	02HX242	12254	32.25	18.99	38	36	174	0.0	88.1	5.8	3.2	95.9	1.0
24	02HX241	12499	34.11	18.36	37	35	169	2.8	87.0	5.8	3.1	97.9	1.3

A104

TEST 7402-2. RHIZOMANIA CODED VARIETY TESTS, SALINAS, CA, 2002

(cont.)

Code No.	Variety	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Stand Count No.	Harv. Count No.	Beets/100' No.	Root Rot %	RJAP %	Powdery Mildew Score	Rhizomania Resistance DI	Rhizomania Resistance %R(0-4)	Seg Pat Code
25	Beta 4430R	14066	37.40	18.81	39	37	178	5.7	89.8	4.0	2.5	98.6	1.3
26	02HX226R	11878	31.59	18.76	31	31	149	0.8	86.3	5.5	3.6	78.0	2.0
27	02HX212R	11287	28.75	19.63	31	31	139	0.0	84.4	6.5	3.4	89.8	1.8
28	02HX229R	10877	27.74	19.58	40	39	182	1.7	86.4	7.0	3.2	99.3	1.3
29	7KJ0191	14063	35.25	19.95	35	36	160	0.0	88.8	6.0	2.8	99.2	1.3
30	9GK7014	16778	45.41	18.45	35	36	160	0.0	88.7	2.8	2.8	100.0	1.0
31	Acclaim	10872	28.27	19.27	38	39	173	0.0	86.5	7.5	3.2	100.0	1.0
32	02HX246	13152	36.81	17.86	37	37	167	0.0	87.9	4.8	3.1	95.9	1.8
33	HH-142	13994	36.65	19.13	36	36	164	0.0	86.9	4.0	3.1	97.2	1.3
34	02HX217	12027	32.94	18.25	15	15	80	1.8	86.4	4.8	3.1	96.8	1.3
35	Crystal R062	16306	41.08	19.89	40	40	193	0.0	88.2	3.8	2.9	96.4	1.0
36	01HX016	10696	27.40	19.51	38	40	172	0.0	87.0	6.0	3.3	96.2	1.3
37	Falcon	13722	35.96	19.11	36	37	164	0.0	87.0	4.3	3.2	96.0	1.5
38	02HX213	13599	34.43	19.77	25	26	128	0.0	84.2	5.5	3.4	91.4	1.0
39	HH-145	12303	32.53	18.90	30	30	139	0.7	86.2	6.0	3.1	92.5	1.8
40	02HX245	12067	34.56	17.45	36	34	163	0.0	88.1	6.0	3.3	90.5	1.8
41	02HX212	10201	25.90	19.69	34	34	164	0.8	84.6	6.0	3.5	86.6	1.5
42	02HX202	12887	36.14	17.82	36	35	167	0.0	87.9	6.8	3.1	96.3	1.0
43	00HX051	12107	32.67	18.54	36	37	164	0.0	85.9	5.5	3.5	81.6	2.0
44	9GK7138	13525	37.71	17.94	38	39	178	0.0	87.8	2.0	2.8	100.0	1.0
45	0GK1638	13684	36.23	18.89	39	38	177	0.0	88.1	1.8	2.9	98.6	1.0
46	02HX210	12528	33.27	18.83	36	38	166	0.0	88.7	6.0	3.1	97.5	1.0
47	02HX205	13425	35.11	19.15	37	36	170	2.0	89.0	5.5	3.0	99.2	1.0
48	02HX219	12645	31.93	19.83	35	35	160	0.0	86.6	5.5	3.1	94.2	1.3
49	Crystal R061	12844	32.31	19.77	35	35	162	1.4	88.7	6.0	3.5	77.5	2.0
50	02HX248	12463	34.38	18.11	36	36	164	0.0	89.7	5.3	3.1	97.7	1.0

(cont.)

| Code No. | Variety | Acre Yield | | Sucrose | Stand Count | Harv. Count | Beets/100' | Root Rot | RJAP | Powdery Mildew | Rhizomania Resistance | | Seg Pat |
		Sugar Lbs	Beets Tons	%	No.	No.	No.	%	%	Score	DI	%R(0-4)	Code
51	0GK1643	15875	41.78	19.00	42	42	189	0.0	89.4	2.5	2.9	98.8	1.0
52	02HX239	12309	33.07	18.59	25	25	119	0.0	86.4	6.0	3.1	91.7	1.5
53	0GK1630	13934	39.14	17.88	38	38	176	0.7	89.1	5.5	3.0	99.3	1.0
54	00HX052	14409	39.36	18.34	35	35	160	0.0	88.6	5.8	3.3	97.1	1.0
55	9J5382	15398	38.56	20.00	37	37	167	0.0	88.7	3.8	2.9	99.3	1.3
56	02HX215	13212	35.37	18.75	27	24	124	0.0	86.9	5.5	3.1	94.0	1.3
57	9GK7003	15855	43.71	18.17	34	34	156	0.0	87.6	2.0	2.9	100.0	1.0
58	Phoenix	14410	39.48	18.26	36	36	164	0.0	88.0	6.3	3.1	96.7	1.0
59	Raptor	14451	40.66	17.79	34	33	154	0.8	88.9	5.3	3.2	96.9	1.0
60	1GK0057	15927	41.98	18.98	39	38	179	0.0	88.6	2.8	2.8	100.0	1.0
61	01HX002	10303	27.05	19.05	36	36	165	0.0	86.4	6.8	3.8	67.9	2.5
62	Beta 4001R	15937	42.28	18.85	35	36	160	0.0	89.1	2.5	2.7	99.3	1.0
63	00HX010	15326	42.81	17.92	34	35	156	0.0	90.1	5.0	3.2	95.1	1.0
64	02HX208	14846	39.33	18.88	11	11	78	0.0	85.8	5.0	2.5	100.0	1.0
65	02HX240	10307	30.66	16.85	38	37	174	1.9	87.3	5.3	3.7	70.5	2.5
66	SS-NB7R	12111	32.54	18.61	37	36	170	0.0	87.3	4.8	3.4	86.3	1.8
67	02HX237	14259	40.02	17.86	19	19	98	0.0	88.5	4.8	3.0	100.0	1.0
68	HH-141	13201	35.59	18.55	38	38	173	0.0	87.6	6.3	3.2	96.7	1.3
69	02HX211	11975	31.10	19.25	31	30	142	2.3	84.5	6.0	3.3	87.0	1.3
70	Beta 4200R	16234	40.95	19.83	37	38	167	0.0	88.1	4.0	2.6	99.4	1.0
71	Beta 4300R	13698	35.37	19.40	30	30	139	1.5	88.4	6.5	3.1	97.0	1.3
72	9GK1596	15068	40.51	18.61	34	33	157	0.0	88.0	2.5	2.7	100.0	1.3
73	02HX206	15180	40.86	18.59	35	35	166	0.0	89.6	6.0	3.1	95.4	1.3
74	00HX056	10832	27.33	19.84	38	38	173	0.0	87.5	7.3	3.2	96.6	1.0
75	9GK7015	15907	43.07	18.46	33	33	151	2.3	89.0	2.5	2.6	100.0	1.0
76	9GK7021	16165	43.32	18.66	36	36	165	0.0	89.1	2.3	2.9	100.0	1.0

TEST 7402-2. RHIZOMANIA CODED VARIETY TESTS, SALINAS, CA, 2002

(cont.)

Code No.	Variety	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Stand Count No.	Harv. Count No.	Beets/ 100' No.	Root Rot %	RJAP %	Powdery Mildew Score	Rhizomania Resistance DI	Rhizomania Resistance %R(0-4)	Seg Pat Code
77	Alpine	13949	39.00	17.89	34	34	159	0.0	90.1	5.0	2.8	100.0	1.3
78	9GK7016	16027	42.33	18.96	39	37	175	2.4	88.4	3.3	2.9	99.3	1.0
79	US H11	7632	24.00	15.89	38	36	180	3.9	85.4	8.0	4.4	45.5	2.8
80	Rodeo	13051	34.58	18.88	34	33	156	0.0	87.4	8.0	3.1	95.6	1.3
81	02HX244	12762	33.97	18.81	38	35	174	7.3	89.2	5.8	3.3	91.3	1.3
82	02HX243	12217	32.25	18.94	38	36	174	1.9	88.2	6.0	3.3	95.2	1.5
83	0GK1633	15213	40.74	18.69	39	37	177	1.7	88.8	2.8	2.8	100.0	1.0
USDA entries													
84	US H11	6991	22.46	15.63	29	36	135	0.0	87.0	7.0	4.3	45.8	3.0
85	Rizor	12519	32.72	19.16	35	36	162	0.8	86.7	5.5	3.3	92.5	1.0
86	Angelina	14111	36.02	19.61	38	38	172	0.0	87.7	7.8	2.9	100.0	1.0
87	Y190H5	13331	35.91	18.59	18	18	92	0.0	86.7	5.0	3.1	96.8	1.3
88	Y175H5	14153	39.46	18.00	27	27	129	0.0	85.5	4.8	3.0	96.7	1.3
89	1927-4H5	14402	39.35	18.34	29	28	137	0.7	85.6	5.3	3.0	95.2	1.3
90	1929-62H5	14937	40.41	18.51	27	26	135	4.5	86.7	4.3	3.1	94.1	1.0
91	1930-35H5	13189	33.26	19.84	32	31	146	3.4	85.8	5.5	3.0	98.1	1.3
92	Beta 6600	10646	27.11	19.66	33	32	158	6.4	88.2	5.8	4.3	52.1	3.0
93	1931H5	14307	38.57	18.55	28	28	136	1.9	86.8	5.0	3.1	97.4	1.0
94	1941H5	13596	36.03	18.85	25	23	122	4.6	87.2	4.5	3.0	96.6	1.5
95	CR111H5	14350	39.22	18.26	26	26	128	0.0	86.2	5.0	3.1	96.7	1.0
96	Z125H5	13795	35.50	19.45	29	28	140	2.5	86.8	5.0	3.1	94.6	1.3
Mean		13405.5	35.95	18.67	34.2	33.8	158.3	0.9	87.8	5.1	3.1	93.8	1.3
LSD (.05)		1629.6	4.42	0.75	5.4	5.4	23.0	4.1	1.7	1.4	0.3	8.4	0.5
C.V. (%)		8.7	8.83	2.88	11.3	11.4	10.4	320.4	1.4	19.5	6.6	6.4	27.3
F value		9.1**	9.09**	8.91**	8.2**	8.2**	7.2**	1.2NS	5.3**	8.4***	9.6**	11.4**	6.3**

A107

(cont.)

Code No.	Variety	Acre Yield		Sucrose %	Stand Count No.	Harv. Count No.	Beets/ 100' No.	Root Rot %	RJAP %	Powdery Mildew Score	Rhizomania Resistance		Seg Pat Code
		Sugar Lbs	Beets Tons								DI	%R(0-4)	

NOTES: Because of severity of trials the past two years, this test was planted 2 weeks earlier into cooler soil. After planting, the test was judiciously sprinkler irrigated to get emergence, but not to promote damping-off and root diseases. Combined with the continuous cool conditions in 2002, rhizomania developed lightly and sugarbeets grew well. Based upon border effects, it appeared that by early September most nitrogen had been depleted, but the crop retained a full canopy through to harvest. Other than as noted below, diseases and pests did not appear to be a problem. The plots were hand harvested, individual roots scored for rhizomania, and placed in two sample bags for clean-tared weight and % sugar analyses.

Entries: Entered by USDA, USH11 & Beta 6600 were susceptible checks. Rizor & Angelina were resistant checks. Angelina (KWS) is reported to have resistance from both Holly (Rz) and WB42 (C48). C833-5HO = C833-5CMS = RzmmCMS from USDA. Y090, C929-62, C930-35, 0931, 0941, CR11 & Z025 are MM,Rz lines & populations from USDA, Salinas. Y075 & C927-4 have resistance from both Rz & Bvm (C51).

Harvest Count: Number of roots counted and scored at harvest per plot. Number of roots = 135 per entry.

Beets/100': Number of plants per 100 ft. of row, counted post thinning.

Root Rot %: Frequency of roots with noticeable root rot, most caused by Sclerotium rolfsii, the cause of Southern rot. Rotted roots were scored for rhizomania when possible, included in gathered beets for weighing, but were discarded prior to running samples through the sugar lab.

Powdery Mildew Score: Mildew was controlled until late in the season. Just prior to harvest, powdery mildew was scored on a scale of 0 to 9, where 9 = 90-100% of leaf area covered. Even though scores were moderately high, powdery mildew would have had little overall influence on sugar yield.

RJAP = raw juice apparent purity = 100(%sugar/%soluble solids).

Rhizomania Scores: All 8 reps were hand harvested and scored. Reps 1-4 on 10/23-25/02 & reps 5-8 on 11/18-21/02. After being lifted, the roots were hand shaken to remove soil and laid out. Each individual root was scored on a scale of 0 to 9, where 9 is most severe. Roots scored 0 to 4 were considered resistant and 5 to 9 were susceptible. Most resistant roots were scored as 3's and most susceptible ones as 5's. Following scoring all beets were topped and placed into two sample bags. After washing, the samples were run through the sugar lab.

A108

TEST 7402-2.   RHIZOMANIA CODED VARIETY TESTS, SALINAS, CA, 2002

(cont.)

| Code No. | Variety | Acre Yield | | Sucrose | Stand Count | Harv. Count | Beets/ 100' | Root Rot | RJAP | Powdery Mildew | Rhizomania Resistance | | Seg Pat |
		Sugar Lbs	Beets Tons	%	No.	No.	No.	%	%	Score	DI %	%R(0-4)	Code

Rhizomania Scores (cont.): After reps 1-4 were harvested, and root symptoms observed to be milder than expected, Reps 5-8 were visually rated for canopy or foliar scores, where 1 = uniformly resistant; 2 = segregating for greener (resistant) and more yellow plants (susceptible); and 3 = uniformly more yellow (susceptible to rhizomania). The frequency of green vs. yellow plants (segregation) was not taken into account, but in general, values close to 1 would be uniformly green (resistant) and values close to 3 would be uniformly yellow (susceptible).

The reaction to rhizomania was mild in this test. Rhizomania tests with good results were run in this same field plot area 4 years earlier and were adjacent to the 2001 test area. Because of the severity in 2001, precautions were used to decrease the effects of disease. The rhizomania tests were planted 2 weeks earlier into cooler soil and then irrigated carefully to help prevent development of soilborne problems. In addition, the 2002 season was consistently cool. Based upon foliage color (yellowing), rhizomania was a factor but most infection occurred on the lateral roots where scoring is difficult and the tap roots of all plants grew more or less normally.

Coefficients of correlations were individually calculated:

	% Resist	HC	SY	RY	%S	SP
Disease Index	-0.87**	-0.00NS	-0.64**	-0.59**	-0.19**	0.61**
% Resistant		0.03NS	0.58**	0.51**	0.26**	-0.73**
Harvest Count			-0.02NS	-0.05NS	0.09NS	-0.01NS
Sugar Yield				0.95**	0.12*	-0.55**
Root Yield					-0.18**	-0.51**
% Sucrose						-0.18**

A109

TEST B102. EVALUATION OF EXPERIMENTAL HYBRIDS, IMPERIAL VALLEY, 2001-2002

24 entries x 8 reps., RCB(E)
1-row plots, 18 ft. long

Planted: September 14, 2001
Harvested: May 13, 2002

Variety	Description		Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Bolters %	Clean Beets %	NO3-N Mean
Checks									
Beta 4430R	rec'd 8-31-01		12964	47.22	13.76	129	0.0	88.0	425
Phoenix	rec'd 8-16-01		10165	38.37	13.25	129	0.6	91.8	419
Topcrosses to Y90									
Y190H50	C790-15CMS	x Y090	8272	32.61	12.71	112	2.5	88.0	379
Y190H5	0833-5HO	x Y090	9101	28.37	15.78	108	1.9	86.8	313
Y190H6	0833-5H50	x Y090	8013	31.38	12.80	117	3.5	87.1	347
Y190H45	9867-1HO	x Y090	7938	32.18	12.33	117	4.3	88.9	385
Y190H2	9831-3HO	x Y090	8418	33.73	12.48	111	0.5	88.6	344
Y190H27	9831-4HO	x Y090	7958	34.54	11.52	95	0.0	90.5	395
Y190H28	0831-4-7HO	x Y090	7102	34.04	10.28	107	0.0	91.1	434
Y190H29	0831-4-10HO	x Y090	8650	40.58	10.68	117	0.0	90.5	415
Y190H62	0836-1H5	x Y090	7488	31.71	11.79	92	0.7	89.7	406
Y190H63	0836-7H5	x Y090	7924	31.28	12.63	99	0.6	89.3	318
Y190H64	0834-2H5	x Y090	8504	35.61	11.93	114	0.6	87.6	440
Y190H67	0837-6H5	x Y090	7939	30.47	13.05	115	0.0	87.7	334
Y190H82	0833-5H2	x Y090	8821	33.92	13.05	106	0.8	89.3	288
Y190H83	0833-5H27	x Y090	8524	34.67	12.32	109	0.0	87.0	383
Y190H84	0833-5H45	x Y090	8580	34.40	12.50	113	3.3	88.5	381
Y190H85	0833-5H46	x Y090	7914	30.20	13.15	119	0.0	87.2	305

A110

TEST B102. EVALUATION OF EXPERIMENTAL HYBRIDS, IMPERIAL VALLEY, 2001-2002

(cont.)

Variety	Description			Acre Yield		Sucrose	Beets/ 100'	Bolters	Clean Beets	NO3-N
				Sugar Lbs	Beets Tons	%	No.	%	%	Mean
Topcrosses to popn-931										
1931H50	C790-15CMS	x	0931	9527	38.04	12.50	123	1.2	87.5	385
1931H5	0833-5HO	x	0931	7637	30.53	12.50	115	1.3	85.7	342
1931H2	9831-3HO	x	0931	8595	35.24	12.15	128	0.0	88.0	393
1931H27	9831-4HO	x	0931	8598	39.39	10.89	117	0.0	89.7	480
1931H28	0831-4-7HO	x	0931	8196	35.93	11.37	111	0.0	89.9	486
1931H29	0831-4-10HO	x	0931	8120	36.35	11.03	117	0.0	88.5	509
Mean				8539.6	34.62	12.35	113.3	0.9	88.6	387.8
LSD (.05)				1562.8	4.92	1.55	17.2	2.1	2.7	54.9
C.V. (%)				18.6	14.43	12.75	15.4	237.5	3.1	14.4
F value				4.2**	5.34**	4.18**	2.3**	2.8**	2.5**	8.7**

A111

TEST B202. EVALUATION OF HYBRIDS WITH SELF-STERILE POLLINATORS, IMPERIAL VALLEY, 2001-2002

48 entries x 8 reps., RCB(E)
1-row plots, 18 ft. long

Planted: September 13, 2001
Harvested: May 14, 2002

Variety	Description		Acre Yield		Sucrose	Beets/ 100'	Bolters	Clean Beets	NO3-N
			Sugar Lbs	Beets Tons	%	No.	%	%	Mean
Checks									
Beta 4776R	rec'd 8-31-01		10467	35.83	14.63	144	0.5	88.7	277
Beta 4430R	rec'd 8-31-01		12288	42.20	14.58	149	0.5	87.4	316
Phoenix	rec'd 8-16-01		10738	38.31	13.98	142	0.9	92.7	363
HH 141	rec'd 8-16-01		9480	34.80	13.61	142	2.0	89.5	352
Hybrids with FS lines									
R178H50	C790-15CMS	x RZM-ER-% R978	9329	33.83	13.86	143	4.6	87.5	254
R178-5H50		x R978-5	9601	36.20	13.28	151	1.0	89.4	295
R178-6H50		x R978-6	10830	39.77	13.68	149	1.4	87.9	272
R178-11H50		x R978-11	9607	33.98	14.12	156	0.4	88.3	249
Y169H50	C790-15CMS	x RZM-ER-% Y969	8855	33.35	13.27	151	16.8	88.7	302
Y168-8H50		x Y968-8	10051	34.71	14.46	141	3.1	88.1	257
Y168-13H50		x Y968-13	9586	32.87	14.57	137	3.1	88.5	267
Y168-16H50		x Y968-16	10171	36.60	13.93	152	4.2	88.2	249
R180H50	C790-15CMS	x RZM-ER-% R980	9959	36.18	13.82	147	16.4	90.4	263
R180-11H50		x R980-11	9895	34.97	14.16	138	0.9	87.9	255
R180-16H50		x R980-16	9945	36.27	13.70	139	5.1	90.2	331
R180-21H50		x R980-21	9993	34.39	14.55	149	1.4	89.6	243
R176-89H50	C790-15CMS	x R076-89	9408	37.29	12.60	137	13.2	90.1	335
R176-89-5H50		x RZM R076-89-5	9899	37.68	13.17	149	4.3	89.3	323
R176-89-5-4-H50		x R976-89-5-4	9755	34.30	14.26	140	0.4	88.5	258
R176-89-5NB-4H50		x R976-89-5NB-4	9561	34.83	13.78	139	3.9	91.2	262

A112

(cont.)

Variety	Description	Acre Yield		Sucrose	Beets/100'	Bolters	Clean Beets	NO3-N
		Sugar Lbs	Beets Tons	%	No.	%	%	Mean
Hybrids with FS lines (cont.)								
R176-89-5-13H50	C790-15CMS x R976-89-5-13	8731	31.99	13.66	143	3.4	89.9	303
R181-22H50	x R981-22	10145	35.95	14.19	150	0.4	89.1	291
Y167H50	x RZM-ER-% Y967	9450	34.52	13.65	140	8.8	90.0	370
Y167-5H50	x Y967-5	10490	37.95	13.85	156	6.9	89.5	275
Y171H50	C790-15CMS x RZM-ER-% Y971	8853	32.93	13.41	149	7.3	88.2	288
Y172-1H50	x Y972-1	9866	36.86	13.38	150	8.1	84.8	292
Y172-5H50	x Y972-5	9876	35.81	13.78	149	4.6	87.0	285
Y172-7H50	x Y972-7	9871	37.91	13.13	144	0.4	90.0	308
Y175H50	C790-15CMS x Y075	9419	36.39	13.01	144	7.7	91.6	273
Y175-13H50	x Y975-13	9625	35.38	13.58	145	13.1	88.3	262
Y190H50	x Y090	8859	33.82	13.06	124	8.9	91.1	283
R170H50	x RZM-ER-% R970	10195	37.55	13.54	147	6.0	89.2	294
P129H50	C790-15CMS x PMR-RZM P029-#(C)	10305	35.20	14.63	145	6.3	89.3	221
P130H50	x PMR-RZM P030-#(C)	10550	38.72	13.65	133	25.0	90.8	276
P118-6H50	x P918-6	9908	36.08	13.68	138	15.0	88.2	262
P125-12H50	x P925-12	7726	28.56	13.61	145	27.9	85.9	254
R143H50	C790-15CMS x RZM-ER-% R943	9678	35.15	13.82	136	31.7	86.9	233
R140H50	x RZM-ER-% R940,R954	9841	36.22	13.60	142	16.1	88.2	260
R136H50	x RZM-ER-% R936	8613	34.13	12.60	146	11.1	85.5	309
Retests from 2000 seed								
R078-4H50	C790-15CMS x R878-4	10557	38.61	13.68	149	0.0	89.3	317
R078-8H50	x R878-8	9172	34.47	13.35	145	4.0	88.5	296
Y067-3H50	x Y867-3	11145	40.01	13.94	128	13.0	91.1	261
R080-9H50	x R880-9	10224	36.48	14.05	136	2.9	88.2	282
R069-18H50	x Y869-18	9978	34.48	14.50	143	2.8	87.6	267

A113

TEST B202. EVALUATION OF HYBRIDS WITH SELF-STERILE POLLINATORS, IMPERIAL VALLEY, 2001-2002

(cont.)

| Variety | Description | Acre Yield | | Sucrose | Beets/100' | Bolters | Clean Beets | NO3-N |
		Sugar Lbs	Beets Tons	%	No.	%	%	Mean
Retests from S$_1$aa x C78 (2000 seed)								
R078H10-17	9810-17aa x R978	10671	37.82	14.11	141	3.9	89.1	265
R078H10-19	9810-19aa x R978	9982	35.88	13.94	131	1.6	88.8	224
R078H35-8	9835-8aa x R978	9241	31.88	14.50	142	0.5	88.9	231
R078H48-1	9848-1aa x R978	8495	30.84	13.78	138	2.9	85.0	217
Mean		9810.1	35.62	13.79	143.2	6.8	88.8	279.5
LSD (.05)		1120.9	3.90	0.72	14.5	5.3	2.5	67.8
C.V. (%)		11.6	11.10	5.27	10.3	79.8	2.9	24.6
F value		7.7**	3.04**	3.78**	1.6*	15.0**	3.2**	2.1**

TEST B302. EVALUATION OF HYBRIDS WITH S_1 PROGENY LINE POLLINATORS, IMPERIAL VALLEY, CA, 2001-2002

48 entries x 8 reps., RCB(e)
1-row plots, 18 ft. long

Planted: September 13, 2001
Harvested: May 17, 2002

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Bolters %	Clean Beets %	NO3-N Mean
Checks								
HH 141	rec'd 8-16-01	10243	34.13	15.04	131	0.0	89.1	201
Phoenix	rec'd 8-16-01	12832	41.29	15.53	134	0.5	93.4	174
Beta 4776R	rec'd 8-31-01	12037	38.43	15.61	131	2.1	88.8	163
Beta 4430R	rec'd 8-31-01	13641	42.55	16.00	137	4.4	89.0	157
Retests & new seed productions								
CR009-1H50	C790-15CMS x CR909-1,(CR09-1)	9305	33.85	13.81	133	15.2	86.1	273
Z025-9H50	x Z825-9,(CZ25-9)	10842	32.72	16.57	140	0.0	87.3	126
0930-19H50	x 8930-19,(C930-19)	12591	40.40	15.61	149	2.9	89.8	135
1930-19H50	x NB 8930-19	10982	36.32	15.19	129	0.0	89.2	156
1927-4H50	C790-15CMS x RZM 9927-4,(C927-4)	9264	31.05	15.23	133	7.0	86.6	145
1929-62H50	x RZM 9929-62,(C929-62)	11951	39.88	14.96	142	4.4	89.9	169
1930-35H50	x RZM 9930-35,(C930-35)	11684	37.54	15.54	128	0.0	90.2	176
1929-4H50	x RZM 9929-4	11125	36.73	15.13	135	8.1	91.6	205
1924-2H50	x RZM 9924-2	11267	37.99	14.85	142	1.6	89.3	168
0936-10H50	x 8936-10	12035	39.04	15.36	129	6.3	88.3	166
Checks								
1942H50	C790-15CMS x RZM 0942	11409	37.82	15.04	122	4.4	88.1	153
1924H50	x RZM-ER-% 9924	10697	35.09	15.31	145	11.0	89.0	168
Checks								
1931H50(Iso)	C790-15CMS x RZM-ER-% 9931	10598	33.85	15.67	139	11.6	84.8	108
1931H50(Sp)	x 9931(C)	10182	32.33	15.84	121	4.0	88.6	114
1941H50(Iso)	x RZM-ER-% 9941	11510	38.33	15.05	119	5.7	88.9	151
1941H50(Sp)	x 9941(C)	10317	34.68	15.05	128	8.3	87.6	172

A115

TEST B302. EVALUATION OF HYBRIDS WITH S_1 PROGENY LINE POLLINATORS, IMPERIAL VALLEY, CA, 2001-2002

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Bolters %	Clean Beets %	NO3-N Mean
Selected S_1 lines	C790-15CMS							
1931-56H50	x 9931-56	11122	35.50	15.68	131	4.8	89.4	111
1931-201H50	x 9931-201	12072	40.45	14.92	126	1.6	89.0	134
1935-6H50	x 9935-6	9209	29.66	15.71	140	8.3	88.1	137
1936-14H50	x 9936-14	11868	37.59	15.87	129	0.0	87.9	103
Checks								
Z125H50	C790-15CMS x Z025(C)	9493	30.69	15.42	128	9.6	87.2	127
Selected S_1 lines	C790-15CMS							
Z131-14H50	x Z931-14	10927	33.39	16.35	133	1.8	84.3	105
Z131-18H50	x Z931-18	12176	38.89	15.86	131	0.4	86.2	111
Z131-20H50	x Z931-20	11128	35.86	15.65	126	9.7	89.7	163
Check								
CR111H50	C790-15CMS x CR11(C)	11082	39.61	14.11	116	5.1	88.8	213
Selected S_1 lines	C790-15CMS							
CR110-14-2H50	x CR910-14-2	10534	35.19	15.03	131	2.5	87.2	139
CR110-5H50	x CR910-5	8752	31.60	13.85	126	20.4	87.0	275
CR112-5H50	x CR812-5	11860	37.70	15.77	134	33.5	88.8	135
Population hybrids	C790-15CMS							
1932H50	x RZM-ER-% 9932	10535	35.18	15.04	116	0.5	84.5	124
1933H50	x RZM-ER-% 9933	10933	34.48	15.91	127	6.9	87.0	127
N124H50	x NR-RZM N024	11009	37.47	14.74	133	3.7	84.4	176
FC1030H50	x FC1030(C)	9244	30.65	15.28	127	16.7	87.0	147
Testcross hybrids to C833-5CMS	0833-5HO							
1931H5	x 0931	10912	35.75	15.35	121	4.6	86.0	126
1941H5	x 0941	10150	32.72	15.62	112	3.2	87.4	110
1942H5	x RZM 0942	11485	36.43	15.75	135	0.5	87.0	100
FC1030H5	x FC1030(C)	10719	34.71	15.53	113	20.5	88.2	121

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolters %	Clean Beets %	NO3-N Mean
Testcross hybrids to C833-5CMS (cont.)								
CR111H5	0833-5HO x CR11(C)	10527	34.84	15.35	115	6.2	86.5	138
Z125H5	x Z025(C)	10255	32.32	15.90	127	8.6	86.9	122
0930-19H5	9833-5HO x 8930-19	11802	36.63	16.20	133	0.0	87.0	105
1930-35H5	0833-5HO x RZM 9930-35	9438	29.40	16.11	120	0.0	89.5	120
1927-4H5	x RZM 9927-4	11787	37.53	15.69	138	6.5	86.2	120
1929-62H5	x RZM 9929-62	13095	42.15	15.54	122	2.7	90.7	116
1929-4H5	x RZM 9929-4	11585	36.27	16.03	115	0.0	88.3	139
1924-2H5	x RZM 9924-2	10333	31.68	16.32	129	0.0	87.4	99
Mean		11011.4	35.80	15.44	129.2	5.8	88.0	146.3
LSD (.05)		1566.5	4.92	0.87	19.9	20.8	2.9	53.9
C.V. (%)		14.4	13.94	5.73	15.7	367.0	3.4	37.5
F value		3.6**	3.45**	3.42**	1.4NS	0.8**	3.0**	4.1**

TEST B402. IMPERIAL VALLEY CODED MID-HARVEST YIELD TEST, IMPERIAL VALLEY, CA, 2001-2002

27 entries x 8 reps, RCB
2-row plots, 18 ft. long

Planted: September 13, 2001
Harvested: June 3 & 4, 2002

Code	Variety	Source	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Bolters %	Clean Beets %	NO3-N Mean
CBGA entries									
1	7KJ0191	Betaseed	11565	35.95	16.04	139	0.2	93.3	186
2	9GK1596	Betaseed	11227	35.66	15.77	131	3.8	90.8	193
3	02HX208	Spreckels	11969	38.58	15.47	80	4.2	93.5	192
4	0GK1638	Betaseed	11782	39.80	14.78	136	0.8	92.5	217
6	0GK1643	Betaseed	13114	42.75	15.30	145	4.2	91.1	215
7	Beta 4001R	Betaseed	13060	44.18	14.79	141	13.0	92.9	300
8	HH141	Spreckels	11438	38.62	14.82	135	0.9	93.7	223
9	Beta 4430R	Betaseed	14556	46.75	15.55	139	0.7	92.7	201
10	0GK1642	Betaseed	12967	43.49	14.89	137	1.1	93.3	268
11	Beta 4035R	Betaseed	10959	37.23	14.73	139	4.8	92.0	194
13	9GK7014	Betaseed	14593	47.99	15.17	145	7.1	93.0	253
14	02HX209	Spreckels	13127	46.52	14.10	137	0.5	94.8	208
15	02HX211	Spreckels	10169	32.34	15.79	101	19.8	93.5	159
16	02HX218	Spreckels	11819	37.97	15.57	134	3.9	91.0	197
17	99HX975	Spreckels	13068	41.68	15.70	113	2.4	93.2	202
18	9GK7003	Betaseed	13988	48.81	14.34	134	1.6	92.2	242
19	02HX215	Spreckels	10901	34.58	15.77	97	16.3	95.9	171
20	02HX217	Spreckels	11818	38.23	15.45	120	4.7	91.8	203
21	US H11	Standard check	8474	30.77	13.77	135	0.0	89.9	202
22	02HX212	Spreckels	10502	32.49	16.12	124	18.4	92.0	125
23	02HX216	Spreckels	11169	38.61	14.46	116	15.6	93.3	230
24	02HX210	Spreckels	10920	36.07	15.16	137	0.5	93.8	240
25	02HX213	Spreckels	10505	33.02	15.88	93	14.8	93.1	146
26	02HX219	Spreckels	12255	39.28	15.60	125	7.6	91.4	206

A118

TEST B402. IMPERIAL VALLEY CODED MID-HARVEST YIELD TEST, IMPERIAL VALLEY, CA, 2001-2002

(cont.)

Code	Variety	Source	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolters %	Clean Beets %	NO3-N Mean
CBGA entries (cont.)									
27	Beta 4776R	Betaseed	11385	37.31	15.25	139	1.8	91.6	248
28	0GK1633	Betaseed	13148	43.75	15.02	145	2.0	92.5	223
USDA filler									
1929-62H5	C833-5CMS x C929-12	USDA	12789	42.02	15.27	129	0.3	93.7	176
Mean			11972.9	39.42	15.21	127.5	5.6	92.6	208.1
LSD (.05)			1327.2	3.81	0.73	15.3	3.6	1.4	81.4
C.V. (%)			11.2	9.79	4.87	12.2	66.1	1.5	40.0
F value			8.7**	13.14**	5.16**	9.8**	23.0**	7.0**	1.6*

A119

TEST B402. IMPERIAL VALLEY CODED MID-HARVEST YIELD TEST, IMPERIAL VALLEY, CA, 2001-2002

Code	Variety	Recover. Sugar lbs/a	Recover. Sugar lbs/t	Recover. Sugar %	Known SugarLoss lbs/a	Sodium ppm	Potassium ppm	NH2-N ppm	Impur. Value
CBGA entries									
1	7KJ0191	9912	275	85.5	1653	712	3276	493	15361
2	9GK1596	9661	272	86.0	1566	690	2965	488	14462
3	02HX208	10019	258	83.4	1950	707	3609	577	16978
4	0GK1638	10000	250	84.2	1782	798	3077	489	15131
6	0GK1643	11119	259	84.1	1996	990	3114	468	15693
7	Beta 4001R	10975	248	83.4	2085	1029	3288	431	15919
8	HH141	9612	249	83.7	1826	817	3164	517	15684
9	Beta 4430R	12583	268	86.0	1973	752	3085	401	14153
10	0GK1642	10813	248	83.2	2154	1063	3070	537	16500
11	Beta 4035R	9165	247	83.5	1794	814	3516	461	16017
13	9GK7014	12309	256	84.0	2284	976	3252	459	15911
14	02HX209	10818	233	82.3	2309	871	3378	522	16451
15	02HX211	8675	270	85.4	1494	689	3368	454	15143
16	02HX218	10016	264	84.4	1802	720	3319	526	15814
17	99HX975	10941	263	83.5	2127	772	3551	567	16964
18	9GK7003	11756	241	83.7	2233	799	3347	418	15131
19	02HX215	9399	272	86.2	1503	698	3027	458	14364
20	02HX217	9877	259	83.6	1941	788	3414	580	16800
21	US H11	6860	223	80.8	1614	773	3418	651	17433
22	02HX212	9112	279	86.3	1390	706	3066	453	14443
23	02HX216	9306	241	83.2	1864	733	3409	520	16024
24	02HX210	9265	257	84.7	1655	674	3211	511	15246
25	02HX213	8968	271	85.1	1538	737	3239	518	15595
26	02HX219	10354	263	84.3	1902	751	3435	523	16188

TEST B402. IMPERIAL VALLEY CODED MID-HARVEST YIELD TEST, IMPERIAL VALLEY, CA, 2001-2002

(cont.)

Code	Variety	Recover. Sugar lbs/a	Recover. Sugar lbs/t	Recover. Sugar %	Known SugarLoss lbs/a	Sodium ppm	Potassium ppm	NH2-N ppm	Impur. Value
CBGA entries (cont.)									
27	Beta 4776R	9890	265	86.6	1495	698	2686	451	13445
28	0GK1633	11201	256	84.7	1947	806	3186	434	14908
USDA filler									
	1929-62H5	10853	260	84.8	1936	695	3221	495	15185
Mean		10128.0	257.3	84.3	1844.9	787.5	3247.9	496.3	15590.5
LSD (.05)		1270.1	18.8	2.7	318.8	213.2	393.9	115.0	2175.3
C.V. (%)		12.7	7.4	3.2	17.5	27.4	12.3	23.5	14.1
F value		6.9**	3.9**	1.9**	5.2**	2.0**	2.0**	1.9*	1.5NS

NOTES: This is the original variety list. The seed obtained for replanting was not used. Stand establishment and uniformity were more variable than normal. Powdery mildew was not controlled and became moderate in late season. No other disease and pest problems appeared significant.

A121

TEST B502. EVALUATION UNDER RHIZOMANIA OF HYBRIDS WITH S$_1$ PROGENY LINE POLLINATORS,
IMPERIAL VALLEY, CA, 2001-2001

48 entries x 8 reps., RCB(E)
1-row plots, 18 ft. long

Planted: September 14, 2001
Harvested: May 14, 2002

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolters %	Clean Beets %	NO3-N Mean
Commercial Checks								
HH141	rec'd 8-16-01	7134	22.82	15.73	176	0.0	92.8	184
Phoenix	rec'd 8-16-01	9138	28.88	15.90	177	0.0	94.5	195
Beta 4776R	rec'd 8-31-01	8910	26.80	16.78	180	0.0	91.3	154
Beta 4430R	rec'd 8-31-01	10670	31.23	17.10	174	0.0	93.2	125
Retests & new seed productions								
CR009-1H50	C790-15CMS x CR909-1,(CR09-1)	7739	24.13	16.16	172	2.1	88.5	117
Z025-9H50	x Z825-9,(CZ25-9)	8491	24.75	17.16	183	0.0	89.4	123
0930-19H50	x 8930-19,(C930-19)	8822	26.53	16.58	179	0.4	91.3	91
1930-19H50	x NB 8930-19,(C930-19)	7859	24.44	16.23	179	0.0	89.1	124
1927-4H50	C790-15CMS x RZM 9927-4,(C927-4)	9001	28.83	15.65	175	0.0	91.1	137
1929-62H50	x RZM 9929-62,(C929-62)	8992	29.04	15.38	170	0.0	91.3	140
1930-35H50	x RZM 9930-35,(C930-35)	7695	23.71	16.42	174	0.3	89.7	135
1929-4H50	x RZM 9929-4	8847	26.42	16.74	186	1.1	90.1	133
1924-2H50	x RZM 9924-2	7935	25.18	16.00	177	0.0	90.0	146
0936-10H50	x 8936-10	9201	29.04	16.08	177	0.0	90.5	155
Checks								
1942H50	C790-15CMS x RZM 0942	8477	28.23	15.15	163	1.2	91.2	165
1924H50	x RZM-ER-% 9924	8004	25.63	15.74	177	1.5	91.0	144

A122

TEST B502. EVALUATION UNDER RHIZOMANIA OF HYBRIDS WITH S_1 PROGENY LINE POLLINATORS, IMPERIAL VALLEY, CA, 2001-2001

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Bolters %	Clean Beets %	NO3-N Mean
Checks								
1931H50(Iso)	C790-15CMS x RZM-ER-% 9931	7650	24.98	15.45	163	1.4	87.5	130
1931H50(Sp)	x 9931(C)	8255	27.07	15.36	167	2.0	90.3	160
1941H50(Iso)	x RZM-ER-% 9941	6841	22.35	15.67	167	1.4	89.3	144
1941H50(Sp)	x 9941(C)	7495	23.39	16.26	166	0.4	88.0	127
Selected S_1 lines								
1931-56H50	C790-15CMS x 9931-56	8804	26.95	16.39	172	1.3	91.2	107
1931-201H50	x 9931-201	9260	29.44	15.79	176	0.0	90.6	127
1935-6H50	x 9935-6	6254	19.41	16.18	165	1.3	87.4	108
1936-14H50	x 9936-14	8608	25.88	16.65	170	0.0	89.9	103
Check								
Z125H50	C790-15CMS x Z025(C)	6981	23.05	15.30	166	0.4	89.3	170
Selected S_1 lines								
Z131-14H50	C790-15CMS x Z931-14	6761	20.07	16.91	177	0.0	86.8	101
Z131-18H50	x Z931-18	8023	24.76	16.28	172	0.0	87.0	110
0929-112H50	C790-15CMS x 8929-112	9420	27.77	17.05	166	0.0	92.2	103
Check								
CR111H50	C790-15CMS x CR11(C)	8104	26.20	15.48	171	2.6	90.5	125
Selected S_1 lines								
CR110-14-2H50	C790-15CMS x CR910-14-2	6801	21.57	15.94	162	0.0	89.0	123
CR110-5H50	x CR910-5	7034	21.71	16.27	177	14.6	88.1	137
CR112-5H50	x CR812-5	8266	26.98	15.43	172	5.6	90.7	207

TEST B502. EVALUATION UNDER RHIZOMANIA OF HYBRIDS WITH S_1 PROGENY LINE POLLINATORS, IMPERIAL VALLEY, CA, 2001-2001

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolters %	Clean Beets %	NO3-N Mean
Population hybrids								
1932H50	C790-15CMS x RZM-ER-% 9932	6902	22.29	15.64	165	0.4	87.2	136
1933H50	x RZM-ER-% 9933	7513	24.43	15.52	170	2.1	89.8	181
N124H50	x NR-RZM N024	8632	27.35	15.93	173	0.4	88.0	131
FC1030H50	x FC1030(C)	6553	21.59	15.27	170	5.7	89.4	114
Testcross hybrids to C833-5CMS								
1931H5	0833-5HO x 0931	7870	24.19	16.35	146	0.0	89.8	90
1941H5	x 0941	8828	26.86	16.42	158	0.4	90.7	104
1942H5	x RZM 0942	7316	22.04	16.64	168	0.0	90.8	95
FC1030H5	x FC1030(C)	7744	24.54	15.98	169	6.6	90.0	121
CR111H5	x CR11(C)	8031	24.73	16.35	157	0.4	90.2	93
Z125H5	x Z025(C)	8080	24.01	16.72	149	0.9	91.0	115
0930-19H5	9833-5HO x 8930-19	8445	25.28	16.77	178	0.9	89.9	83
1930-35H5	0833-5HO x RZM 9930-35	7742	22.35	17.49	163	1.9	89.6	91
1927-4H5	0833-5HO x RZM 9927-4	9315	28.79	16.24	175	1.2	91.0	119
1929-62H5	x 9929-62	8993	27.91	16.19	167	0.9	90.6	124
1929-4H5	x RZM 9929-4	8123	23.83	17.31	156	0.0	90.5	113
1924-2H5	x RZM 9924-2	8513	25.09	17.08	161	0.0	91.1	86
Mean		8126.5	25.26	16.19	169.8	1.2	90.1	127.9
LSD (.05)		1194.8	3.66	0.79	14.3	2.5	2.2	46.0
C.V. (%)		14.9	14.70	4.94	8.5	202.4	2.5	3.7
F value		4.4**	4.04**	4.45**	2.5NS	7.8**	4.1**	3.0NS

TEST B602. EVALUATION OF HYBRIDS WITH SELF-STERILE POLLINATORS UNDER RHIZOMANIA,
IMPERIAL VALLEY, CA, 2001-2002

Planted: September 14, 2001
Harvested: June 3, 2002

48 entries x 8 reps., RCB(E)
1-row plots, 18 ft. long

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Bolters %	Clean Beets %	NO3-N Mean
Checks								
Beta 4776R	rec'd 8-31-01	10178	28.45	17.89	186	0.3	91.4	62
Beta 4430R	rec'd 8-31-01	12429	34.74	17.90	173	1.0	93.7	79
Phoenix	rec'd 8-16-01	9857	28.78	17.22	181	1.0	93.2	109
HH 141	rec'd 8-16-01	8603	25.85	16.80	168	0.4	93.8	131
Hybrids with FS lines								
R178H50	C790-15CMS x RZM-ER-% R978	8580	24.16	17.75	181	2.7	89.7	35
R178-5H50	x R978-5	8348	24.29	17.21	170	0.4	89.9	75
R178-6H50	x R978-6	9957	29.65	16.89	180	0.4	91.3	89
R178-11H50	x R978-11	9464	26.91	17.61	177	0.0	91.0	43
Y169H50	C790-15CMS x RZM-ER-% Y969	8520	24.37	17.66	181	7.1	90.7	53
Y168-8H50	x Y968-8	9235	25.95	17.89	177	0.0	89.3	52
Y168-13H50	x Y968-13	7718	22.25	17.50	177	1.1	90.7	46
Y168-16H50	x Y968-16	8997	25.36	17.84	179	0.8	90.5	73
R180H50	C790-15CMS x RZM-ER-% R980	8215	22.89	17.90	178	5.0	90.8	46
R180-11H50	x R980-11	8450	24.22	17.49	177	0.7	88.5	63
R180-16H50	x R980-16	8877	25.07	17.72	167	1.3	91.8	88
R180-21H50	x R980-21	9750	27.18	17.93	171	0.0	92.3	64
R176-89H50	C790-15CMS x R076-89	9091	25.57	17.79	169	4.6	93.1	46
R176-89-5H50	x RZM R076-89-5	9222	25.79	17.93	161	2.2	90.2	40
R176-89-5-4-H50	x R976-89-5-4	8943	24.37	18.30	168	0.0	89.7	53
R176-89-5NB-4H50	x R976-89-5NB-4	9155	25.56	17.98	172	0.4	92.0	31

(cont.)

| Variety | Description | Acre Yield | | Sucrose | Beets/100' | Bolters | Clean Beets | NO3-N |
		Sugar Lbs	Beets Tons	%	No.	%	%	Mean
Hybrids with FS lines (cont.)								
R176-89-5-13H50	C790-15CMS x R976-89-5-13	8675	24.12	18.05	175	0.7	89.6	43
R181-22H50	x R981-22	8502	24.18	17.67	170	0.0	91.4	40
Y167H50	x RZM-ER-% Y967	10100	28.22	17.90	172	4.4	90.6	33
Y167-5H50	x Y967-5	10859	30.76	17.67	177	3.0	92.5	51
Y171H50	C790-15CMS x RZM-ER-% Y971	8344	24.11	17.28	174	2.4	90.8	34
Y172-1H50	x Y972-1	10192	28.90	17.65	179	5.7	88.1	44
Y172-5H50	x Y972-5	9125	26.27	17.39	174	1.7	89.6	46
Y172-7H50	x Y972-7	10144	30.33	16.81	181	0.0	91.7	43
Y175H50	C790-15CMS x Y075	9180	26.74	17.16	172	4.2	90.8	42
Y175-13H50	x Y975-13	10249	29.30	17.54	172	8.7	91.0	34
Y190H50	x Y090	8665	25.22	17.20	141	3.6	91.2	59
R170H50	x RZM-ER-% R970	8991	25.73	17.67	165	4.1	90.7	33
P129H50	C790-15CMS x PMR-RZM P029-#(C)	9539	25.93	18.45	183	2.2	89.5	30
P130H50	x PMR-RZM P030-#(C)	9929	28.05	17.70	170	13.5	92.0	56
P118-6H50	x P918-6	9850	27.82	17.76	170	4.3	89.4	35
P125-12H50	x P925-12	7550	21.17	17.82	170	14.7	88.8	33
R143H50	C790-15CMS x RZM-ER-% R943	9991	27.53	18.10	174	23.7	90.7	34
R140H50	x RZM-ER-% R940,R954	9112	25.35	17.97	170	12.2	89.8	35
R136H50	x RZM-ER-% R936	8898	25.91	17.19	174	9.3	90.7	38
Retests from 2000 seed								
R078-4H50	C790-15CMS x R878-4	9837	28.23	17.34	172	0.0	90.6	47
R078-8H50	x R878-8	7826	22.96	16.94	174	1.2	90.8	38
Y067-3H50	x Y867-3	10993	30.96	17.75	163	4.5	92.1	42
R080-9H50	x R880-9	7357	20.82	17.73	177	0.0	87.8	22
R069-18H50	x Y869-18	9026	25.58	17.67	179	0.8	91.4	45

A126

TEST B602. EVALUATION OF HYBRIDS WITH SELF-STERILE POLLINATORS UNDER RHIZOMANIA,
IMPERIAL VALLEY, CA, 2001-2002

(cont.)

Variety	Description	Acre Yield		Sucrose	Beets/ 100'	Bolters	Clean Beets	NO3-N
		Sugar Lbs	Beets Tons	%	No.	%	%	Mean
Retests from S₁aa x C78 (2000 seed)								
R078H10-17	9810-17aa x R978	10111	27.91	18.12	185	1.3	90.9	55
R078H10-19	9810-19aa x R978	10721	30.38	17.63	155	1.3	92.0	48
R078H35-8	9835-8aa x R978	8644	24.15	17.89	170	1.7	91.8	49
R078H48-1	9848-1aa x R978	9468	27.05	17.52	161	1.5	90.5	44
Mean		9280.6	26.36	17.64	172.8	3.3	90.8	50.6
LSD (.05)		1424.8	4.00	0.69	13.6	3.8	1.9	41.4
C.V. (%)		15.6	15.39	3.99	8.0	114.7	2.2	83.0
F value		3.6**	3.56**	2.21**	2.6NS	11.9**	3.8**	2.0**

TEST B802. PERFORMANCE OF LINES WITH HIGH RESISTANCE UNDER RHIZOMANIA, IMPERIAL VALLEY, CA., 2001-2002

24 entries x 4 reps, sequential
1-row plots, 18 ft. long

Planted: September 14, 2001
Harvested: June 6, 2002

Variety	Description	Acre Yield Sugar lbs	Beets Tons	Sucrose %	Beets/100' No.	Bolters %	Clean Beets %	NO3-N Score	Appear Score Mean
Checks									
Phoenix	rec'd 8-16-01	5618	18.03	15.61	153	0.0	92.8	179	3.8
Beta 4430R	rec'd 8-31-01	7008	20.70	16.99	167	0.0	92.8	105	3.1
US H11	1999 production	2274	8.59	13.40	165	0.0	89.2	103	4.2
R021	RZM R926,R927,(C26,C27)	3358	11.12	14.74	168	2.5	89.3	122	3.3
Hybrid-line combinations									
Y190	RZM Y090	3804	11.57	16.37	145	0.0	92.8	82	3.4
Y190H50	C790-15CMS x RZM Y090	4857	14.23	17.02	149	0.0	90.5	69	3.5
Y190H5	C833-5HO x RZM Y090	4738	13.61	17.43	140	0.0	91.8	77	3.5
Y175	RZM Y075	8433	28.49	14.82	168	4.1	93.2	89	2.2
Y175H50	C790-15CMS x RZM Y075	6400	21.15	15.13	172	1.7	93.0	91	2.4
Y175H5	C833-5HO x RZM Y075	8823	25.87	17.05	181	0.0	95.4	68	2.1
1927-4	RZM 9927-4aa x A,(C927-4)	7641	24.19	15.83	160	0.0	92.5	84	2.4
1927-4H50	C790-15CMS x RZM 9927-4	9952	29.72	16.75	168	0.7	91.2	45	1.8
1927-4H5	0833-5HO x RZM 9927-4	9206	27.16	16.96	168	0.0	91.8	60	2.1
Lines and Populations									
P007/8 (CP07)	PMR-RZM P807-2,-8;P808-7	7410	22.16	16.73	174	0.0	92.9	55	2.0
P118-6 (CP08)	Inc. P918-6	7232	20.43	17.77	165	1.0	91.8	32	2.0
P125-12	Inc. P925-12	2283	7.20	16.05	158	11.3	86.7	41	4.1
N112	NR-RZM P912 (A,aa)	8321	25.16	16.54	175	8.9	91.6	48	1.8
N172	NR-RZM N972 (A,aa)	6711	21.67	15.51	164	25.9	90.8	92	2.4
Y167	RZM-ER-% Y967, (C67)	6117	18.10	16.99	161	5.3	93.7	52	2.7
Y167-5	Inc. Y967-5	6744	20.46	16.60	165	1.1	93.7	47	2.4
Y172-1	Inc. Y972-1	6331	20.66	15.32	164	0.8	90.3	69	1.8
Y172-5	Inc. Y972-5	4068	12.18	16.74	164	0.0	89.8	43	2.8
Y172-7	Inc. Y972-7	6985	21.60	16.08	174	0.0	92.8	65	2.2
Y175-13	Inc. Y975-13	7433	24.58	15.25	164	12.5	93.5	94	1.9

(cont.)

| Variety | Description | Acre Yield | | Sucrose | Beets/100' | Bolters | Clean Beets | NO3-N | Appear Score |
		Sugar Lbs	Beets Tons	%	No.	%	%	Score	Mean
Mean		6322.8	19.53	16.15	163.9	3.2	91.8	75.3	2.7
LSD (.05)		1720.8	5.22	1.25	30.7	5.5	2.0	58.5	0.7
C.V. (%)		19.3	18.96	5.48	13.3	124.5	1.6	55.1	18.5
F value		11.8**	11.56**	5.34**	0.8NS	9.6**	6.7**	2.4**	9.4**

NOTES: See tests B1202 and B702, and B1002-B1302. The purpose of test B802 was to evaluate breeding lines and increases of progeny lines that had previously been identified/selected for resistance and appearance under severe rhizomania in the Imperial Valley. Test B702 was grown under moderate rhizomania in field K. This is the 2nd cycle of rhizomania tests following soil inoculation. Most of the entries in B802 and B1202 have resistance to rhizomania conditioned by Rz and/or from wild beets, particularly from C51 (R22,Bvm) and/or WB242 & WB97. The combination of components of sugar yield and appearance scores were used to confirm the presence of high resistance to rhizomania and/or other soil-borne problems.

R021 = sugarbeet x *B.v.maritima* but from C26 & C27, not C51 or WB242.

Y190 = MM,O.P. line with Rz.

Y175 = composite of selections for high resistance to rhizomania with C51 and *Rz* germplasm.

1927-4 = C927-4, reselection of S1 line with resistance from C51 and *Rz*.

P007/8 = line to be released as CP07 in 2002 with WB242, WB97, & C51 germplasm and resistance to powdery mildew (*Pm*).

P118-6 = line to be released as CP08 in 2002 with *Rz* and resistance to powdery mildew (*Pm*) from WB242.

Appears also to be resistant to phytotoxemia from the feeding of *Empoasca* leaf hoppers.

N112 = line with *Rz* and *Pm* and germplasm from WB242 and selected for resistance to sugarbeet cyst nematode at Salinas.

N172 = line with germplasm from WB accessed from KWS and reported to have resistance to cyst nematode.

Y167-5 = increase of FS progeny that appeared to have resistance to rhizomania from C51.

Y172-# = increases of FS progenies with C51 germplasm in C37 background.

Y175-13 = increase of FS progeny from line Y75.

Appearance score: (= beauty score) rating of canopy prior to harvest. Mean scores were from ratings made 5/17/02, 6/3/02 and 6/6/02, where 1 is best and 5 is worst. 1 = estimated to be how canopy (size, color, vigor, chlorosis, necrosis, survival, ...) would look in the absence of rhizomania. 5 = plants stunted, dead, dying and in very poor general health. Score 3 approximates how lines with only *Rz* factor would rate.

TEST B702. FULL-SIB AND S_1 PROGENY PERFORMANCE UNDER RHIZOMANIA, IMPERIAL VALLEY, 2001-2002

96 entries x 2 reps., sequential
1-row plots, 18 ft. long

Planted: September 14, 2001
Harvested: June 5 & 6, 2002

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Bolters %	Clean Beets %	NO3-N Mean	Appearance Score 6/3/02
Checks									
Beta 4430R	rec'd 8-31-01	9638	28.00	17.42	164	0.0	90.3	117	3.0
Phoenix	rec'd 8-16-01	9030	28.14	16.17	133	0.0	92.8	200	3.5
US H11	1999 production	3680	12.95	14.86	150	0.0	88.9	71	4.0
Y175	Inc. Y75(C)	9545	30.26	15.90	161	0.0	93.9	136	1.5
99-C31/6	Inc. F86-31/6 (C31/6)	5278	15.86	16.34	142	0.0	94.1	57	3.5
Y191	Inc. FS(C)	8831	26.07	17.13	145	2.2	93.4	100	2.0
1927-4H5	0833-5HO x RZM 9927-4	9180	29.00	15.87	150	3.3	91.5	124	2.0
Y167	RZM-ER-% Y967, (C67)	10169	28.42	17.96	183	4.7	93.1	59	2.0
FS's from Y75									
Y175 - 1	RZM Y075(PX)	6128	17.44	17.53	145	3.4	91.5	67	3.0
- 2		11728	36.45	16.09	133	0.0	94.7	107	1.0
- 3		7111	20.10	17.79	128	0.0	94.2	44	2.5
- 4		10100	28.75	17.53	139	1.9	92.1	91	2.5
- 5		8352	24.31	17.33	125	0.0	92.3	58	1.0
- 6		8078	24.29	16.72	128	0.0	91.4	70	2.0
- 7		12880	38.45	16.86	125	0.0	94.6	105	2.5
- 8		12561	35.66	17.60	156	0.0	95.7	39	1.5
- 9		11254	34.11	16.51	139	0.0	94.4	68	2.0
-10		9897	28.54	17.34	133	0.0	93.6	51	3.0
-11		7145	22.13	16.14	122	0.0	88.9	90	2.0
-12		8524	22.62	18.76	145	0.0	95.4	42	3.0
-13		10651	30.34	17.59	139	0.0	90.9	33	1.5
-14		6475	18.47	17.52	120	19.0	91.6	27	4.0
-15		7931	23.54	16.82	133	18.8	93.4	74	4.0
-16		10179	28.70	17.70	170	0.0	91.9	67	2.5

A130

TEST B702. FULL-SIB AND S₁ PROGENY PERFORMANCE UNDER RHIZOMANIA, IMPERIAL VALLEY, 2001-2002

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Bolters %	Clean Beets %	NO3-N Mean	Appearance Score 6/3/02
FS's from Y75 (cont.)									
Y175 -17	RZM Y075 (PX)	7558	22.30	16.98	139	0.0	94.0	52	2.5
-18		7652	22.69	16.98	128	0.0	90.2	65	3.5
-19		7912	22.50	17.64	128	2.2	93.9	62	3.0
-20		10215	29.56	17.27	117	9.6	95.9	51	1.5
-21		9908	27.17	18.20	150	0.0	94.3	41	3.5
-22		11420	34.76	16.48	131	0.0	93.3	86	2.0
-23		8277	23.03	17.97	125	0.0	91.6	39	3.0
-24		6507	21.37	15.27	147	5.6	92.8	95	3.5
S₁'s from 0934									
1934 -101	RZM 0934⊗	4798	15.34	15.77	147	0.0	91.4	81	2.0
-102		7061	22.02	15.98	120	4.3	90.9	91	3.5
-103		8557	26.89	15.99	131	8.8	93.0	103	2.0
-104		5450	16.51	16.50	106	0.0	94.5	51	3.5
-105		4333	13.03	16.99	92	18.8	93.6	40	4.0
-106		6866	22.54	15.39	139	0.0	90.6	82	3.0
-107		6666	21.04	15.83	117	0.0	95.6	32	4.5
-108		10065	29.68	17.01	147	8.0	95.0	67	3.0
-109		3427	11.38	15.38	117	0.0	92.2	47	2.5
-110		10949	35.15	15.46	122	0.0	93.9	122	2.5
S₁'s from 0921									
1921 - 1	RZM 0921⊗	10490	32.94	15.93	145	1.9	91.3	119	3.0
- 2		4103	11.31	18.20	117	0.0	91.1	35	3.5
- 3		6178	19.18	16.08	153	3.6	91.0	49	3.0
- 4		8794	26.14	16.68	128	0.0	94.6	147	4.5
- 5		9009	30.05	15.03	131	57.2	94.1	56	3.0
- 6		5050	15.20	16.61	120	2.5	89.7	38	5.0
- 7		2517	8.18	15.20	122	0.0	91.0	34	5.0

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Bolters %	Clean Beets %	NO3-N Mean	Appearance Score 6/3/02
S_1's from 0921 (cont.)									
1921 - 8	RZM 0921⊗	7243	22.07	16.41	106	35.6	91.6	66	3.5
- 9		6254	18.44	16.92	131	0.0	94.1	20	3.0
-10		3572	9.97	17.85	136	2.6	91.9	32	3.5
S_1's from N024									
N124 - 1	RZM N024(galls)⊗	7471	21.61	17.29	108	15.5	88.0	56	3.0
- 2		7088	23.85	14.65	111	0.0	92.0	99	3.5
S_1's from N065m									
N165 - 1	N065(galls)mm⊗	5499	18.48	14.85	95	0.0	91.6	104	4.0
S_1's from N972									
N172 - 1	NR-RZM N972⊗	6669	21.59	15.51	136	0.0	90.4	36	3.0
- 2		7734	25.66	15.05	95	0.0	92.0	156	3.0
S_1's from P912									
N112 - 1	NR-RZM P912⊗	6310	21.73	14.53	128	0.0	90.4	36	3.5
- 2		4198	12.53	16.72	139	0.0	86.1	38	4.0
- 3		6460	19.96	15.81	156	0.0	88.9	81	2.5
- 4		5665	19.15	15.11	28	0.0	93.8	62	3.5
- 5		9249	26.10	17.67	139	4.0	91.2	57	2.0
- 6		6658	21.43	15.55	136	24.5	89.5	44	2.0
- 7		8334	24.88	16.74	108	0.0	93.0	27	3.5
- 8		7453	23.68	15.78	106	34.2	90.5	43	3.0

TEST B702. FULL-SIB AND S_1 PROGENY PERFORMANCE UNDER RHIZOMANIA, IMPERIAL VALLEY, 2001-2002

(cont.)

Variety	Description	Acre Yield Sugar lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Bolters %	Clean Beets %	NO3-N Mean	Appearance Score 6/3/02
FS's from P921-6 (maybe $S^f{:}S^sS^s$)									
P121 -6- 1	P921-6(PX)	9565	31.67	15.10	131	0.0	95.5	47	3.5
-6- 2		8613	24.89	17.36	153	16.5	92.0	27	2.0
-6- 3		9660	27.77	17.39	161	32.8	92.5	20	2.0
-6- 4		7780	22.84	17.07	128	19.6	92.5	25	3.0
-6- 5		8245	23.61	17.46	133	0.0	90.3	29	2.5
-6- 6		8675	25.64	16.92	178	42.2	92.9	22	2.0
-6- 7		9288	28.09	16.53	147	0.0	92.9	42	2.5
-6- 8		7906	24.41	16.17	125	28.7	90.9	22	2.0
-6- 9		7375	22.39	16.52	133	35.2	93.4	44	3.0
-6-10		9516	28.60	16.56	156	13.7	92.2	24	3.0
FS's from P918-8									
P118 -8- 1	P918-8(PX)	6592	19.44	16.91	114	0.0	92.2	39	3.0
-8- 2		10596	32.54	16.30	133	64.5	92.7	91	2.5
-8- 3		6125	20.43	14.99	103	54.4	92.0	68	3.5
-8- 4		6670	20.49	16.19	114	53.5	88.6	30	3.0
-8- 5		9447	27.70	17.04	147	53.6	91.6	23	3.0
-8- 6		7051	22.94	15.41	100	35.8	93.8	42	3.5
-8- 7		6416	20.33	15.66	97	16.7	93.2	49	3.0
-8- 8		9303	29.68	15.62	133	63.6	95.1	64	3.0
S_2's from 9926-11									
1926 -11-1	9926-11⊗	5271	16.79	15.55	81	13.0	94.5	46	3.5
-11-2		5987	21.87	13.76	95	20.0	93.4	58	3.0
-11-3		8762	27.64	15.93	117	0.0	96.1	38	2.0
-11-4		5271	18.10	14.64	86	2.6	95.1	73	4.0

TEST B702. FULL-SIB AND S_1 PROGENY PERFORMANCE UNDER RHIZOMANIA, IMPERIAL VALLEY, 2001-2002

(cont.)

Variety Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Bolters %	Clean Beets %	NO3-N Mean	Appearance Score 6/3/02
S_2's from 9926-15								
1926 -15-1 9926-15⊗	5067	16.01	15.84	142	0.0	93.5	18	4.0
-15-2	7667	23.58	16.26	111	0.0	90.1	21	3.5
-15-3	3984	12.17	16.22	117	0.0	94.6	15	4.0
-15-4	3066	9.58	16.03	131	1.9	90.1	14	4.5
S_2's from 9934-8								
1934 -8- 1 9934-8⊗	5998	18.61	16.00	136	4.1	90.7	75	3.5
-8- 2	5197	16.20	16.04	128	0.0	89.3	38	3.0
-8- 3	2470	7.53	16.32	117	17.5	91.6	32	5.0
-8- 4	4520	14.65	15.48	139	0.0	90.3	52	3.0
Mean	7458.8	22.71	16.23	127.8	10.2	91.4	59.4	3.0
LSD (.05)	3378.2	10.16	1.69	30.4	14.0	3.2	48.5	1.1
C.V. (%)	22.8	22.54	5.23	12.0	69.0	1.8	41.2	18.8
F value	4.0**	3.74**	10.39**	5.6**	14.0**	70.1**	4.1**	4.8**

NOTES: See tests B802, B1002-B1302. See test B1102 for additional progeny lines under severe rhizomania.

Test B702 was grown under moderate rhizomania in field K. This is the 2nd cycle of rhizomania tests following inoculation of soil. The primary purpose of tests B702 and B1102 was to identify progeny lines (FS's and S_1's) that perform best under rhizomania in the Imperial Valley. Most of these progeny lines have resistance to rhizomania conditioned by Rz (Holly gene) and from wild beets, particularly from C51 (R22,Bvm) and/or WB242 & WB97. From C51, some advanced progeny lines have high resistance to rhizomania under high temperature conditions. The combination of sugar yield components and appearance scores will be used to identify and confirm these genotypes. Also, residual annualism occurs in this material, and nonbolting, biennials will be selected.

(cont.)

| Variety | Description | Acre Yield | | Sucrose | Beets/ 100' | Bolters | Clean Beets | NO3-N | Appearance Score |
		Sugar Lbs	Beets Tons	%	No.	%	%	Mean	6/3/02

NOTES: (cont.)

Appearance score (= canopy beauty score) of canopy prior to harvest. Ratings were made 6/3/02 where 1 is best and 5 is worst. 1 = relative score of material in test and estimate of how canopy (size, color, vigor, chlorosis, necrosis, …) would look in the absence of rhizomania. 5 = plants stunted, dead or dying and in very poor general health. Score 3 to 5 are types that were thought would not survive under rhizomania in high temperatures of mid-summer.

Y175 & Y175-#s = line and FS progenies from Y75 line that has about 10% C51 (*Bvm*) germplasm and selected for high resistance in Imperial Valley and Salinas. 1934-#s = S$_1$'s from self-fertile, multigerm line with C51 germplasm. 1921-#s = S$_1$'s from self-fertile, multigerm line with germplasm from C51,C26 & C27. N112-#s = S$_1$'s from line P912 that has WB242 germplasm for resistance to cyst nematode and powdery mildew. 1927-4H5 = C833-5CMS x C927-4.

TEST B1002. EVALUATION OF EXPERIMENTAL HYBRIDS FOR RESISTANCE TO RHIZOMANIA UNDER SEVERE CONDITIONS, IMPERIAL VALLEY, CA, 2001-2002

64 entries x 2 reps., sequential
1-row plots, 14 ft. long

Planted: September 14, 2000
Not harvested for yield

Variety	Description	Stand Count	Appearance Score		
		No.	05/16	06/04	Mean
Checks					
B4776R	rec'd 8-31-01	15	2.5	3.0	2.8
US H11	1999 production	15	3.0	2.5	2.8
R522(Sp)	RZM-%S R322R4,…(C51)	16	1.0	2.5	1.8
HH 141	rec'd 8-16-01	17	2.5	3.5	3.0
B4430R	rec'd 8-31-01	21	2.5	3.0	2.8
Phoenix	rec'd 8-16-01	16	3.0	3.5	3.3
Rizor	HH108, 9-3-97	14	3.0	3.0	3.0
R021H50	C790-15CMS x R926,R927,(C26,C27)	15	2.5	3.5	3.0
Hybrids from resistant lines					
Y171H50	C790-15CMS x RZM-ER-% Y971,(C72)	22	2.0	3.0	2.5
Y167H50	x RZM-ER-% Y967,(C67)	13	2.0	2.5	2.3
Y067-3H50	x Y867-3	12	2.0	2.5	2.3
Y167-5H50	x Y967-5	22	2.5	3.0	2.8
Y172-1H50	x Y972-1	26	1.5	2.5	2.0
Y172-5H50	x Y972-5	15	1.5	2.5	2.0
Y172-7H50	x Y972-7	15	2.5	3.0	2.8
Y175-13H50	x Y975-13	15	1.5	2.0	1.8
Y175H50	x RZM Y075(C)	19	2.0	2.0	2.0
R170H50	x RZM-ER-% R970	16	3.0	3.0	3.0
R143H50	x RZM-ER-% R943	14	2.0	2.5	2.3
R140H50	x RZM-ER-% R940,R954	16	2.5	2.5	2.5
R136H50	x RZM-ER-% R936	16	2.5	2.5	2.5
Y190H50	x RZM Y090	5	3.5	3.0	3.3
Y190H3	97-C562HO x RZM Y090	4	3.0	3.5	3.3
Y190H80	0808-9H5 x RZM Y090	7	3.0	3.0	3.0
Y190H81	0808-15HG x RZM Y090	9	3.0	3.0	3.0
Y190H11	CR011aa x RZM Y090	10	2.5	3.0	2.8
Y190H41	0941aa x RZM Y090	10	2.0	3.0	2.5
Y190H25	Z025aa x RZM Y090	4	2.5	3.5	3.0
Y190H31	0931aa x RZM Y090	19	2.5	3.0	2.8
Y190H5	C833-5HO x RZM Y090	1	3.0	4.0	3.5
Y175H5	C833-5HO x RZM Y075(C)	5	2.5	2.5	2.5
Y072-4H50	C790-15CMS x Y872-4	10	2.0	2.5	2.3
R078H50	C790-15CMS x R978,(C78/3)	25	3.0	3.5	3.3

TEST B1002. EVALUATION OF EXPERIMENTAL HYBRIDS FOR RESISTANCE TO RHIZOMANIA
UNDER SEVERE CONDITIONS, IMPERIAL VALLEY, CA, 2001-2002

(cont.)

Variety	Description		Stand Count No.	Appearance Score		
				05/16	06/04	Mean

Hybrids from resistant lines (cont.)

Variety	Description		Stand Count No.	05/16	06/04	Mean
R078H48-1	9848-1aa	x R978	8	2.0	3.0	2.5
R078H10-17	9810-17aa	x R978	10	1.5	3.0	2.3
R078H10-19	9810-19aa	x R978	14	2.5	3.0	2.8
R021H5	C833-5(T-O)HO x R926,R927,(C26,C27)		22	2.5	3.0	2.8
R522(Sp)	RZM-% R322R4, (C51)		11	1.0	1.5	1.3
US H11	1999 production		8	3.5	3.0	3.3
P007/8 H50	C790-15CMS x PMR-RZM P807-2,-8		13	1.5	2.0	1.8
P129H50	C790-15CMS	x PMR-RZM P029-#(C)	21	2.5	3.5	3.0
P130H50		x PMR-RZM P030-#(C)	14	3.5	3.5	3.5
P118-6H50		x P918-6,(CP08)	10	1.0	2.0	1.5
P125-12H50		x P925-12	16	2.5	3.0	2.8
N124H50	C790-15CMS	x NR-RZM N024	8	2.5	3.0	2.8
1931H50(Sp)		x RZM 0931(C)	4	3.0	3.5	3.3
1941H50(Sp)		x RZM 0941(C)	3	3.0	4.0	3.5
CR111H50		x RZM CR011(C)	5	2.5	3.0	2.8
Z125H50	C790-15CMS	x RZM Z025(C)	13	3.5	4.0	3.8
01-FC1030H50		x RZM FC1030(C)	8	3.5	3.5	3.5
0934H50		x RZM 9934	4	1.0	2.0	1.5
1942H50		x RZM 0942	4	3.0	3.5	3.3
R176-89H50	C790-15CMS	x RZM R076-89	10	3.5	3.0	3.3
1927-4H50		x RZM 9927-4,(C927-4)	6	1.0	2.0	1.5
1929-62H50		x RZM 9929-62,(C929-62)	2	4.0	4.0	4.0
1930-35H50		x RZM 9930-35,(C930-35)	7	3.0	3.5	3.3
1929-4H50	C790-15CMS	x RZM 9929-4	10	2.5	3.0	2.8
1924-2H50		x RZM 9924-2	6	4.0	4.0	4.0
1927-4H5	C833-5HO	x RZM 9927-4,(C927-4)	6	3.0	3.0	3.0
1929-62H5		x RZM 9929-62,(C927-62)	5	4.0	4.0	4.0
1930-35H5		x RZM 9930-35,(C930-35)	4	3.0	3.0	3.0
1929-4H5		x RZM 9929-4	1	4.5	4.0	4.3
1924-2H5		x RZM 9924-2	2	4.0	3.5	3.8
Y175H5		x RZM Y075(C)	7	2.0	2.5	2.3
Mean			11.0	2.6	3.0	2.8
LSD (.05)			14.1	1.7	1.1	1.3
C.V. (%)			63.9	33.0	17.9	22.4
F value			1.6*	1.8*	2.4**	2.3**

NOTES: See tests B1102, B1202, B1302, and B702 & B802.

64 entries x 4 reps., sequential   Planted: September 14, 2001
1-row plots, 14 ft. long   Not harvested for yield

Variety	Source Resist	Description	Stand Count No.	Appearance Score 5/17	6/04	Mean
Checks						
Rizor	SES	HH108, 9-3-97	12.5	3.3	3.5	3.4
HH141	Rz	rec'd 8-16-01	15.0	3.5	3.8	3.6
Phoenix	Rz	rec'd 8-16-01	17.3	3.5	4.0	3.8
US H11	--	1999 production	15.8	3.5	4.0	3.8
R522(Sp)	Bvm	RZM-%S R322R4,(C51)	17.8	1.8	2.0	1.9
B4776R	Rz	rec'd 8-31-01	13.0	3.0	3.8	3.4
B4430R	Rz	rec'd 8-31-01	15.8	3.0	3.5	3.3
1927-4H50	Bvm-Rz	C790-15CMS x RZM C927-4	16.3	1.3	1.5	1.4
Multigerm,S^{s}S^s lines						
R039	Q	Inc. R539,(C39R)	16.0	3.3	3.8	3.5
99-C31/6	--	Inc. F86-31/6, (C31/6)	11.8	3.5	4.0	3.8
R176-89	Rz	RZM R076-89	8.3	3.8	4.0	3.9
Y190	Rz	RZM Y090	10.8	3.0	3.3	3.1
Y191	Rz	Inc. FS(C)	14.0	2.3	2.5	2.4
Y167	Bvm	RZM-ER-% Y967,(C67)	17.0	2.0	2.5	2.3
Y175	Bvm-Rz	RZM Y075(C)	16.3	1.5	2.3	1.9
Y171	Bvm	RZM-ER-% Y971,(C72)	16.5	2.5	2.5	2.5
Y067-3	Bvm	Inc. Y867-3	9.5	2.8	3.0	2.9
Y072-4	Bvm	Inc. Y872-4	14.5	2.5	3.3	2.9
Y167-5	Bvm	Inc. Y967-5	16.0	2.8	3.0	2.9
Y172-1	Bvm	Inc. Y972-1	10.8	2.0	2.5	2.3
Y172-5	Bvm	Inc. Y972-5	15.8	2.3	3.0	2.6
Y172-7	Bvm	Inc. Y972-7	13.5	2.3	2.8	2.5
Y175-13	Bvm-Rz	Inc. Y975-13	15.5	1.3	1.8	1.5
P007/8(CP07)	Bvm-Rz	PMR-RZM P807-2;-8;P808-7	16.3	1.5	2.0	1.8
01-C37	--	Inc. U86-37, (C37)	15.8	4.8	5.0	4.9
P127(CP03)	Bvm-Rz	PMR P027-#(C)	19.3	4.3	4.8	4.5
P128(CP04)	Bvm-Rz	PMR P028-#(C)	16.8	1.0	1.0	1.0
P129(CP05)	Bvm-Rz	PMR-RZM P029-#(C)	17.5	4.0	4.3	4.1
P130(CP06)	Bvm-Rz	PMR-RZM P030-#(C)	16.3	3.8	4.3	4.0
R178	Rz	RZM-ER-% R978,(C78/3)	16.5	3.8	3.8	3.8
99-C46/2	--	Inc. U86-46/2,(C46/2)	17.3	4.0	4.5	4.3
01-EL0204	Rz	RZM 00-EL0204	16.3	3.8	4.3	4.0
P118-6(CP08)	Bvm-Rz	Inc. P918-6	13.5	1.0	1.0	1.0
P125-12	Bvm-Rz	Inc. P925-12	19.8	4.8	4.0	4.4
US H11	--	1999 production	18.3	3.8	4.3	4.0
1927-4H5	Bvm-Rz	0833-5HO x 9927-4(C927-4)	19.0	1.5	1.8	1.6

TEST B1202.   EVALUATION OF MULTIGERM LINES FOR RESISTANCE TO RHIZOMANIA
UNDER SEVERE CONDITIONS, IMPERIAL VALLEY, 2001-2002

(cont.)

Variety	Source Resist	Description	Stand Count No.	Appearance 5/17	Score 6/04	Mean
Multigerm,S^{s}S^s lines (cont.)						
R021	*Bvm-Rz*	RZM R926,R927,(C26,C27)	14.5	3.0	3.8	3.4
01-C37	--	Inc. U86-37,(C37)	14.5	4.5	4.8	4.6
R136	*Bvm*	RZM-ER-% R936,(C79-8)	17.3	2.5	3.3	2.9
R143	*Bvm*	RZM-ER-% R943	17.3	1.3	3.0	2.1
Multigerm,S^f,A:aa populations & lines						
N112	*Bvm-Rz*	NR-RZM P912 (A,aa)	16.3	1.0	1.8	1.4
N172	*Bvm-Rz*	NR-RZM N972 (A,aa)	20.3	1.3	1.8	1.5
N124	*Bp-Rz*	NR-RZM N024(g)(A,aa)	14.0	3.0	3.0	3.0
0747	--	Inc. 7747 (A,aa)	18.5	3.8	4.3	4.0
1931(Iso)	*Rz*	RZM-ER-% 9931 (A,aa)	14.5	4.0	4.3	4.1
0926	*Bvm-Rz*	RZM-ER-% 8926(Sp)	13.3	2.3	2.8	2.5
0921	*Bvm-Rz*	9926aa x RZM R926,R927	16.8	2.3	2.3	2.3
01-FC1030	*Rz*	FC1030(C)aa x A	15.5	4.0	4.3	4.1
0934	*Bvm-Rz*	RZM 9934 (A,aa)	14.0	2.5	2.5	2.5
CR111	*Rz*	RZM CR011(C)aa x A	17.5	3.8	3.8	3.8
Z125	*Rz*	RZM Z025(C)aa x A	15.8	4.0	4.3	4.1
1932	*Rz*	RZM-ER-% 9932 (A,aa)	17.0	3.8	4.5	4.1
1924	*Rz*	RZM-ER-% 9924 (A,aa)	17.5	3.8	4.0	3.9
1933	*Rz*	RZM-ER-% 9933 (A,aa)	14.0	3.8	4.3	4.0
1942	*Rz*	RZM 0942aa x A	19.8	3.5	4.0	3.8
1941(Iso)	*Rz*	RZM-ER-% 9941 (A,aa)	15.3	3.0	3.8	3.4
9927-4	*Bvm-Rz*	Inc. 7924-4VY,(C927-4)	11.5	1.3	2.3	1.8
0934-5	*Bvm-Rz*	Inc. 8934-5 (A,aa)	11.5	2.3	2.8	2.5
1929-4	*Rz*	RZM 9929-4	12.3	4.5	4.5	4.5
1924-2	*Rz*	RZM 9924-2	15.3	4.8	4.3	4.5
1927-4	*Bvm-Rz*	RZM 9927-4,(C927-4)	13.3	1.0	1.0	1.0
1930-19	*Rz*	NB 8930-19,(C930-19)	9.8	4.5	5.0	4.8
1930-35	*Rz*	RZM 9930-35,(C930-35)	12.3	4.0	4.5	4.3
1929-62	*Rz*	RZM 9929-62,(C929-62)	12.0	4.8	4.8	4.8
Mean			15.2	3.0	3.3	3.2
LSD (.05)			6.2	0.9	0.8	0.8
C.V. (%)			29.0	21.8	17.4	17.1
F value			1.4*	12.1**	13.4**	16.1**

NOTES: See test B802 and tests B702, B1002, B1102, and B1302. Tests B1002-
B1302 were in a field plot area with severe rhizomania and soil-borne problems
that had been in sugarbeet trials every other year since about 1990. Scored 1
to 5, where 1 is best, on 5/17 by JAO and 6/4 by RTL. Source of resistance:
Rz = Holly gene; *Bvm* = *Beta vulgaris* subsp. *maritima*, including C51, (C50,R22),
WB97, and/or WB242; Q = quantitative resistance; *Bp* = *B.procumbens* for nematode
resistance.

A139

48 entries x 2 reps., sequential   Planted: September 14, 2001
1-row plots, 14 ft. long   Not harvested for yield

Variety	Source Resist	Description	Appearance Score		
			6/03	6/04	Mean
Checks					
Y172-1	*Bmv*	Inc. Y972-1	2.0	2.0	2.0
Y175-13	*Bmv-Rz*	Inc. Y975-13	1.0	1.5	1.3
Y190	*Rz*	RZM Y090	2.5	2.5	2.5
Y190H50	*Rz*	C790-15CMS x RZM Y090	3.0	3.0	3.0
Y190H80	*Rz*	0808-9H5 x RZM Y090	3.5	3.5	3.5
Y190H81	*Rz*	0808-15H5 x RZM Y090	3.0	2.5	2.8
1927-4	*Bmv-Rz*	RZM 9927-4aa x A,(C927-4)	2.5	2.0	2.3
1927-4H50	*Bmv-Rz*	C790-15CMS x RZM 9927-4,(C927-4)	1.5	2.0	1.8
1927-4H5	*Bmv-Rz*	0833-5HO x RZM 9927-4,(C927-4)	3.0	2.5	2.8
Monogerm lines & populations					
1869	*Rz*	RZM,T-O 0869-#(C)mmaa x A,(C869)	4.0	4.0	4.0
1869HO	*Rz*	9869HO x A, (C869CMS)	3.5	3.5	3.5
1835	*Rz*	8835(C)mmaa x A	3.5	3.5	3.5
1835HO	*Rz*	0835HO x 8835(C)A	3.5	3.0	3.3
1842	*Rz*	RZM 0840(C)mmaa x A	3.5	3.0	3.3
1842HO	*Rz*	0841HO x A	4.5	4.0	4.3
1836	*Rz*	0836,0837mmaa x A	4.0	3.5	3.8
1836HO	*Rz*	0836HO x A	3.5	3.5	3.5
1848M	*Bmv-Rz*	RZM 0848 (A,aa)	3.5	3.0	3.3
1848m(H50)	*Bmv-Rz*	mm & CMS x A	3.0	2.0	2.5
01-FC1014	*Rz*	00-FC1014mmaa x A	4.5	3.5	4.0
01-FC1014H5	*Rz*	0833-5HO x A	4.5	3.0	3.8
01-FC1014H7	*Rz*	0833-5(Sp)aa x A	4.5	4.0	4.3
01-FC123	*Rz*	RZM 00-FC123mmaa x A	4.5	4.0	4.3
01-FC123H5	*Rz*	0833-5HO x A	4.0	3.0	3.5
01-FC123H7	*Rz*	0833-5(Sp)aa x A	3.5	4.0	3.8
1835-11	*Rz*	Inc. 8833-11 (A,aa)	5.0	4.5	4.8
1835-11H5	*Rz*	0833-5HO x A	4.0	4.5	4.3
1835-26	*Rz*	Inc. 8835-26 (A,aa)	5.0	4.5	4.8
1835-26H5	*Rz*	0833-5HO x A	4.5	4.0	4.3
Y175	*Bmv-Rz*	RZM Y075,…	1.5	2.0	1.8

TEST B1302.   EVALUATION OF MONOGERM LINES & POPULATIONS FOR RESISTANCE TO
RHIZOMANIA UNDER SEVERE CONDITIONS, IMPERIAL VALLEY, 2001-2002

(cont.)

Variety	Source Resist	Description	Appearance Score		
			6/03	6/04	Mean
Monogerm lines & populations (cont.)					
Y175H50	*Bmv-Rz*	C790-15CMS x RZM Y075,…	2.5	2.0	2.3
Y175H5	*Bmv-Rz*	C833-5HO x RZM Y075,…	2.5	2.5	2.5
Y190H5	*Rz*	*C833*-5HO x RZM Y090	3.5	3.0	3.3
1833-5(Iso)	*Rz*	RZM 0833-5(Sp) (A,aa),(C833-5)	5.0	4.0	4.5
1833-5	*Rz*	Inc. 0833-5(Sp) (A,aa),(C833-5)	5.0	4.5	4.8
1833-5-8	*Rz*	Inc. 8833-5-8 (A,aa)	5.0	4.0	4.5
1833-5-11	*Rz*	Inc. 8833-5-11 (A,aa)	5.0	4.5	4.8
1848M	*Bmv-Rz*	RZM 0848 (A,aa)	3.0	3.0	3.0
1927-4	*Bmv-Rz*	RZM 9927-4aa x A,(C927-4)	1.5	1.5	1.5
Monogerm nematode resistant lines					
N165-9M	*Bp-Rz*	Inc. N065-9 (A,aa)	3.5	3.5	3.5
N165-9HO	*Bp-Rz*	NR-RZM N065H5 x N065-9	2.0	3.0	2.5
N165-9H50	*Bp-Rz*	C790-15CMS x N065-9	2.0	2.5	2.3
N165	*Bp-Rz*	NR-RZM N065mm(g) (A,aa)	4.0	3.0	3.5
N165HO	*Bp-Rz*	NR-RZM N065H5 x " "	4.0	3.5	3.8
N165H50	*Bp-Rz*	C790-15CMS x " "	3.5	3.0	3.3
N167M	*Bp-Rz*	Inc. N067-#(C)(g) (A,aa)	3.5	3.5	3.5
N167HOM	*Bp-Rz*	N065H5(g) x " "	3.5	3.0	3.3
N124	*Bp-Rz*	NR-RZM N024(g) (A,aa)	3.0	3.0	3.0
Mean			3.5	3.2	3.3
LSD (.05)			1.4	1.1	0.6
C.V. (%)			19.6	17.3	8.6
F value			4.8**	4.5**	20.0**

NOTES: See tests B702-B1202.   Test B1302 was in a field plot area with severe
rhizomania and soil-borne problems.   This area has been in sugarbeet trials every
other year since about 1990.   Score 1 to 5, where 1 is best and 5 is poorest.
Scored on successive days due to changes in time of day and experience of scorer.
Source of resistance: *Rz* = Holly gene; *Bvm* = *Beta vulgaris* subsp. *maritima*,
usually C51, (C50,R22); *Bp* = *Beta procumbens* source of nematode resistance; Q =
quantitative resistance.

TEST 5602.   CR PERFORMANCE OF LINES & HYBRIDS, SALINAS, CA, 2002

48 entries x 6 reps, RCB(e)
1-row plots, 11 ft. long

Planted: March 25, 2002
Harvested: November 14, 2002

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Bolting %	Root Rot %	CLS Score
Line Checks									
Y190	RZM Y090,C2,Syn 1	16223	50.35	16.03	118	82.7	0.0	0.0	3.2
Y191	Inc. FS(C),C1,Syn 1	13913	41.87	16.65	139	83.6	0.0	0.0	2.7
Y175	RZM Y075	13864	46.19	14.90	130	80.7	0.0	0.0	3.7
R021	RZM R926,R927,(C26,C27)	15939	52.58	15.18	141	82.8	0.0	0.0	3.8
01-SP22-0	Inc. 00-SP22-0	12052	42.17	14.30	139	82.5	0.0	1.1	2.3
01-EL0204	RZM 00-EL0204 (Rz,smooth root)	13428	46.46	14.38	147	81.6	0.0	0.0	2.8
Lines									
01-FC1030	RZM FC1030aa x A (Rz, Rhizoc.)	12986	42.73	15.08	136	81.5	0.0	1.1	3.3
1933	RZM-ER-% 9933 (Rz, root aphid)	14367	46.87	15.35	133	80.1	0.0	1.0	2.8
1931	RZM 0931aa x A (popn-931)	13368	44.75	14.90	129	83.2	0.0	0.0	2.7
CR111	RZM CR011aa x A (popn-CR11)	13469	45.67	14.75	135	81.8	0.0	1.2	2.3
CR011	RZM CR910,911,912aa x A	14793	47.51	15.58	123	83.3	0.0	0.0	2.7
CR910	RZM R710,R709-9,R710-10,R710-14	13193	45.23	14.65	136	81.0	0.0	0.0	2.3
CR811	RZM CR711, (CR09/10)	16274	52.64	15.45	152	81.5	0.0	0.0	2.5
R106	RZM R006, (Ital. Acc, 1987)	8735	28.53	15.42	112	82.7	0.0	3.1	2.3
1244,5,6(C)	CR(ms) x 0931	14804	51.40	14.40	145	81.8	0.0	0.0	3.8
CR911-7(Sp)	CR811aa x CR811(C),(HS progeny)	14835	46.76	15.87	133	82.9	0.0	0.0	1.7
CR009-1	RZM CR909-1aa x A, (CR09-1)	11647	36.22	16.07	133	82.0	0.0	0.0	3.3
CR110-5	Inc. CR910-5, (Inc. S_1 line)	9734	30.85	15.72	127	82.1	0.0	0.0	2.2
CR110-14-2	Inc. CR910-14-2,(Inc. S_2 line)	10563	34.10	15.43	135	82.0	0.0	0.0	1.5
CR112-5	Inc. CR912-5,(Inc.S_1 line)	10315	40.75	12.65	147	76.9	0.0	1.1	3.0

A142

TEST 5602.   CR PERFORMANCE OF LINES & HYBRIDS, SALINAS, CA, 2002

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Bolting %	Root Rot %	CLS Score
Monogerm lines & F₁ hybrids									
1689	RZM 0869-#mmaa x A, (C869)	15236	49.99	15.15	141	83.0	0.0	0.0	3.3
01-FC123	RZM FC123aa x A (Rz,CLSR)	14808	48.81	15.25	126	82.7	0.0	0.0	3.3
01-FC1014	RZM FC1014aa x A (Rz,Rhizoc)	14903	44.16	16.83	138	83.4	0.0	0.0	2.3
01-FC1014H5	0833-5HO x RZM FC1014	15472	44.99	17.17	135	84.1	0.0	0.0	2.2
01-FC123H5	0833-5HO x RZM FC123	14233	44.81	15.87	126	81.4	1.4	1.4	2.8
Hybrid Checks									
Monohikari	lot 8033, rec'd 2/22/02	14408	44.24	16.28	141	84.9	0.0	3.1	3.3
ACH555	CLSR check,lot #8107307,3/8/02	12902	39.22	16.45	150	82.0	1.0	0.0	2.7
HM-E17	rec'd 3/21/02	14976	44.99	16.68	150	86.1	0.0	0.0	3.0
Dorotea	rec'd 3/21/02	16021	50.39	15.92	139	87.7	0.0	0.0	3.7
Monodoro	rec'd 3/21/02	13046	45.31	14.35	145	82.3	0.0	0.0	3.2
Beta 4776R	rec'd 2/5/02	14553	48.77	14.83	144	82.2	0.0	0.0	3.0
Phoenix	rec'd 8/16/01	13182	47.62	13.73	136	83.3	0.0	0.0	4.2
HH141	rec'd 8/16/01	13361	43.77	15.25	133	83.9	0.0	1.1	3.5
Beta 4430R	rec'd 8/31/01	11485	42.10	13.50	141	82.9	0.0	0.0	5.0
Experimental Hybrids									
Y190H50	C790-15CMS x RZM Y090	15794	51.95	15.18	115	82.5	0.0	1.5	3.0
1931H50	C790-15CMS x RZM 0931	16801	53.88	15.62	136	84.7	0.0	0.0	3.0
1933H50	C790-15CMS x RZM-ER-% 9933	15995	49.43	16.15	133	84.0	9.6	0.0	3.0
CR111H50	C790-15CMS x RZM CR011	14211	48.56	14.57	135	83.6	0.0	0.0	3.3
CR110-14-2H50	C790-15CMS x CR910-14-2	13415	41.85	16.00	133	84.6	9.9	0.0	2.3
CR110-5H50	C790-15CMS x CR910-5	14777	47.87	15.47	136	80.3	0.0	0.0	1.8
CR112-5H50	C790-15CMS x CR812-5	18822	57.41	16.32	144	83.6	0.0	0.0	2.8
CR009-1H50	C790-15CMS x CR909-1	17420	54.23	16.00	147	82.5	0.0	0.0	2.7

A143

TEST 5602. CR PERFORMANCE OF LINES & HYBRIDS, SALINAS, CA, 2002

(cont.)

Variety	Description	Acre Yield		Sucrose	Beets/100'	RJAP	Bolting	Root Rot	CLS Score
		Sugar Lbs	Beets Tons	%	No.	%	%	%	
Experimental Hybrids (cont.)									
Y190H5	0833-5HO x RZM Y090	18752	54.54	17.20	120	83.3	0.0	0.0	2.5
1930-35H5	0833-5HO x 9930-35	14217	40.18	17.68	138	82.8	0.0	0.0	2.3
CR009-1H5	9833-5HO x CR909-1	13773	42.60	16.13	145	82.4	0.0	0.0	2.8
CR111H5	0833-5HO x RZM CR0111	14762	45.80	16.07	133	83.4	0.0	0.0	2.2
1931H5	0833-5HO x RZM 0931	14930	48.08	15.55	136	79.9	0.0	0.0	2.2
01-FC1030H5	0833-5HO x RZM FC1030	14370	43.51	16.48	132	83.9	0.0	0.0	2.5
Mean		14190.1	45.68	15.51	135.9	82.7	0.5	0.3	2.9
LSD (.05)		2550.3	7.17	1.15	13.8	3.5	2.2	1.7	0.7
C.V. (%)		15.8	13.80	6.54	8.9	3.7	432.3	463.2	21.2
F value		4.9**	5.05**	5.62**	3.2**	1.8**	6.0**	1.4NS	7.1**

Notes: Test 5602 was grown in non-rhizomania soil and on August 8, 2002 inoculated with *Cercospora beticola*. Development of CLS was slow, but by harvest, disease development was moderate. Plots were scored 11/12/02 on a scale of 0 to 9.

Downy mildew occurred and in several lines became severe. For example, line CR112-5 was highly infected with downy mildew causing constant defoliation, probably resulting in very low sugar content in contrast to its more resistant hybrid CR112-5H50.

Powdery mildew was controlled to prevent interference with leaf spot development. But frequent sprinkler irrigations used to promote leaf spot may have caused a higher than usual incidence of rust and downy mildew on susceptible entries. For example, Beta 4430R appeared to be more rust susceptible than entries developed at Salinas.

A144

TEST 6002. OBSERVATION & EVALUATION OF LINES FOR REACTION TO CERCOSPORA, SALINAS, 2002

36 entries x 3 reps., sequential
1-row plots, 11 ft. long

Planted: March 25, 2002
Harvested: November 11, 2002

| Variety | Description | Acre Yield | | Sucrose | Beets/100' | RJAP | Root Rot | CLS |
		Sugar Lbs	Beets Tons	%	No.	%	%	Score
Beta 4430R	rec'd 8/31/01	16663	51.28	16.23	139	86.5	0.0	4.3
Dorotea	rec'd 3/21/01	15308	48.64	15.73	139	84.4	0.0	3.3
Monodoro	rec'd 3/21/02	12841	39.01	16.53	145	85.1	0.0	2.0
Ippolita	rec'd 3/25/99	17038	50.14	16.93	142	85.5	0.0	2.0
1931	RZM 0931aa x A	15496	47.68	16.27	145	84.9	0.0	2.3
CR111	RZM CR011aa x A	18228	53.51	17.03	136	84.4	0.0	1.7
CR910	RZM R710,R709-9,R710-10,R710-14	14817	45.82	16.20	145	83.6	0.0	1.7
CR811	RZM CR711, (CR09/10)	14931	46.49	16.07	152	83.7	0.0	1.7
R409	CR-RZM R209-#(C)	13931	45.55	15.30	118	83.0	0.0	2.0
R410	CR-RZM R210-#(C)	11721	41.98	13.73	127	79.6	0.0	2.3
R609	CR-RZM R409, (CR09)	13368	42.84	15.60	130	83.2	0.0	2.3
R609R2	CR-RZM R409R2	17509	51.87	16.87	158	84.2	0.0	1.3
R610	CR-RZM R410	9977	34.13	14.50	142	82.2	0.0	3.3
R610R2	CR-RZM R410R2	16778	50.32	16.70	127	83.8	0.0	2.0
443	MM,CR Accession from Italy	7508	26.08	14.33	103	84.5	0.0	2.0
445	MM,CS Accession from Italy	11204	37.77	15.00	91	84.5	0.0	3.7
1241-1	0931aa x M(PF)	12700	40.82	15.57	121	81.1	0.0	2.3
1241-2	0931aa x M(PF)	16711	53.21	15.70	124	83.2	0.0	3.7
1242-1	0931aa x D(PF)	13945	50.79	13.70	115	78.3	0.0	3.7
1242-2	0931aa x D(PF)	13582	44.08	15.30	124	82.2	0.0	1.7
1243-1	0931aa x I(PF)	21064	57.78	18.13	112	85.9	0.0	2.0
1243-2	0931aa x I(PF)	19429	59.93	16.37	109	84.2	0.0	2.3
1244-1	M(ms) x 0931	14522	47.68	15.23	115	82.7	5.6	3.3
1244-2	M(ms) x 0931	17138	51.73	16.60	127	85.1	2.2	2.0

TEST 6002. OBSERVATION & EVALUATION OF LINES FOR REACTION TO CERCOSPORA, SALINAS, 2002

(cont.)

| Variety | Description | Acre Yield | | Sucrose | Beets/ 100' | RJAP | Root Rot | CLS |
		Sugar Lbs	Beets Tons	%	No.	%	%	Score
1244-3	M(ms) x 0931	17825	50.77	17.43	118	86.2	0.0	1.7
1245-1	D(ms) x 0931	13219	42.65	15.53	103	84.2	6.1	2.7
1246-1	I(ms) x 0931	16367	50.90	16.07	136	86.1	0.0	1.7
1246-2	I(ms) x 0931	17143	55.09	15.60	130	85.4	0.0	2.7
1931	RZM 0931aa x A	15698	49.99	15.67	130	80.9	0.0	2.7
Dorotea	rec'd 3/21/02	16958	49.99	16.97	139	87.0	0.0	2.3
CR009-1H5	9833-5HO x CR009-1	18706	51.60	18.13	139	82.8	0.0	1.7
Z025-9H5	9833-5HO x Z825-9	17954	49.45	18.13	139	82.8	0.0	2.3
Mean		15321.2	47.49	16.04	129.0	83.8	0.4	2.4
LSD (.05)		4554.5	13.19	1.63	25.4	5.0	3.5	1.0
C.V. (%)		18.2	17.02	6.23	12.1	3.7	499.0	25.1
F value		3.2**	2.17*	3.86**	2.9**	1.2NS	1.4NS	4.7**

2002 SALINAS ENTRIES IN FORT COLLINS & BETASEED SHK DISEASE NURSERIES

Variety	Description	Shakopee Tests			Fort Collins	
			CLS	Aph	RA	CLS	
		3Sept	Mean	17Jul		14Sep	5Sep
Comm. ck-1	Beta 4430R	8.18	6.57	3.86	3.64	3.7	4.7
Comm. ck-2	Monohikari	7.14	5.22	3.08	1.36	2.0	3.0
01-SP22-O	Inc. 00-SP22-O	6.16	4.08	3.22		3.3	4.0
1933	RZM-ER-% 9933 (A,aa)	6.41	4.74	3.67	2.83	3.5	3.3
1931	RZM 0931aa x A	7.41	5.15	4.95			
Y191	Cycle 1, Syn 1 FC(C)	7.44	5.08	3.85		3.3	4.0
Y175	RZM Y075	7.28	5.29	4.74	2.27	2.3	3.8
01-FC1030	RZM FC(C)aa x A	6.63	4.62	3.30	1.50	2.7	3.0
01-FC1014	RZM FC1014mmaa x A	7.24	4.70	4.28	1.71	2.0	3.0
01-FC123	RZM FC123mmaa x A	7.08	4.08	4.93	2.43	2.3	3.3
CR011	RZM CR910,911,912aa x A	6.45	4.32			2.7	3.7
CR111	RZM CR0111aa x A	6.88	4.72	4.23	2.60	3.3	4.0
CR011H5	CMS x RZM CR910,11,12	7.05	5.01				
CR111H5	CMS x CR011	6.87	5.27				
CR009-1H5	CMS x CR909-1	7.16	4.60			3.0	3.0
CR009-1	RZM CR009-1aa x A	7.32	4.17			2.0	3.3
CR110-5	Inc. CR910-5	6.18	3.98			2.3	3.7
CR110-14-2	Inc. CR910-14-2	4.86	3.46			2.7	3.7
CR112-5	Inc. CR812-5	7.16	4.89			2.8	4.0
CR110-5H50	CMS x CR910-5	7.05	4.88				
Resist.hyb ck	Betaseed	5.48	3.61	2.10	1.08		
Susc.inbred ck	Betaseed	7.19	4.76	4.03	3.13		
LSS	(SP351069-0)					3.0	4.3
LSR	(FC504 x 502/2) x SP6322-0					3.7	4.0
LSD (.05)		0.75	0.60	0.92		1.04	0.87

Shakopee, MN
CLS test: 2-row plots, 3 reps, Rosemont, MN
Aphanomyces test: 2-row plots, 4 reps, Shakopee, MN
Root aphids, greenhouse test, Shakopee, MN

Fort Collins, CO
CLS test: 2-row plots, 3 reps, 12 ft. long, Fort Collins, CO

TEST 4802. EVALUATION OF POWDERY MILDEW RESISTANT LINES AND PROGENIES, SALINAS, CA, 2002

16 entries x 3 reps., sequential
1-row plots, 11 ft. long

Planted: February 28, 2002
Harvested: October 4, 2002

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Bolting %	Powdery Mildew 9/30
Checks								
P007/8	PMR-RZM P807-2,P808-7,(CP07)	16497	50.53	16.33	155	83.4	0.0	2.0
01-C37	Inc. U86-37, (C37)	13527	41.31	16.37	139	85.8	0.0	8.3
PMR lines								
P118-6	Inc. P918-6,(CP08)	16402	49.72	16.43	152	85.8	0.0	5.0
P125-12	Inc. P925-12	14356	43.27	16.47	145	83.4	0.0	4.3
P129	PMR-RZM P029-#(C),(CP05)	16725	49.72	16.83	152	83.1	0.0	3.0
P130	PMR-RZM P030-#(C),(CP06)	17006	49.99	17.03	155	84.9	0.0	3.7
N112	NR-RZM P912(A,aa),(WB242)	15453	46.77	16.47	136	85.7	0.0	4.3
N172	NR-RZM N972(A,aa),(WBNR)	14908	48.92	15.23	155	84.0	3.9	3.3
PMR progenies								
P121-6-1	P921-6(PX), (C78 x P811)	15311	49.10	15.60	124	83.0	0.0	4.3
P121-6-2	P921-6(PX), (C78 x P811)	13817	43.81	15.80	145	79.8	13.5	1.0
P121-6-3	" "	14833	46.50	15.97	133	83.4	17.3	3.7
P121-6-4	" "	15398	47.30	16.30	127	81.9	23.9	2.3
P118-8-1	P118-8(PX), (C37 x P816)	12368	39.78	15.57	145	83.0	0.0	2.0
P118-8-2	" "	16274	51.07	15.90	124	86.2	0.0	2.3
P118-8-3	" "	12966	40.85	15.87	121	84.9	0.0	2.0
P118-8-4	" "	15681	46.77	16.73	118	87.4	0.0	3.0
Mean		15095.2	46.59	16.18	139.2	84.1	3.7	3.4
LSD (.05)		2769.4	7.40	1.30	28.0	5.6	8.3	2.3
C.V. (%)		11.0	9.52	4.81	12.1	4.0	136.6	40.5
F value		2.1*	2.08*	1.23NS	1.8NS	1.0NS	6.8**	4.6**

Notes: See Test 6802. PMR in P-lines was segregating at difference frequencies.

TEST 5402. EVALUATION OF BREEDING LINES AND POPULATIONS FOR ERWINIA/POWDERY MILDEW, SALINAS, CA, 2002

80 entries x 3 reps., sequential
1-row plots, 17.5 ft. long

Planted: March 25, 2002
Not harvested for yield

Variety	Description	Harv. Count No.	Stand Count No.	Powdery Mildew Score 10/07	10/25	11/01	Mean	Root Rot %	Erwinia Root Rot DI	%Healthy
Multigerm, open-pollinated lines										
US H11	11/3/99 (resistant check)	26.0	27.0	6.0	7.3	6.7	6.7	7.3	11.3	51.4
E740	Inc. E870 (susc. check)	25.3	25.7	5.0	5.7	5.7	5.4	18.2	46.1	22.4
01-US75	Inc. 00-US75, (US75)	27.0	27.0	6.0	7.3	6.7	6.7	7.4	18.2	54.2
01-CTR-PX	Inc. P93191, P93174	25.7	24.3	4.0	5.3	5.3	4.9	4.4	11.8	56.3
01-C37	Inc. U86-C37, (C37)	27.3	27.3	5.3	6.7	6.7	6.2	6.2	10.9	60.3
01-SP22-0	Inc. 00-SP6822-0, (SP22-0)	25.3	25.0	3.3	5.3	5.0	4.6	8.1	12.1	64.4
01-ELO204	RZM 00-ELO204	24.3	24.7	3.0	4.3	5.0	4.1	5.6	11.1	53.8
99-C46/2	Inc. U86-C46/2, (C46/2)	25.3	24.7	2.0	3.7	4.0	3.2	1.5	7.1	66.1
R178	RZM-ER-% R978, (C78/2)	25.0	25.3	1.7	3.3	3.3	2.8	2.9	5.8	73.9
R180	RZM-ER-% R980, (C80/2)	25.0	23.3	2.3	3.3	4.0	3.2	1.5	1.6	90.9
R170	RZM-ER-% R970	25.3	25.7	1.7	3.0	4.3	3.0	5.4	11.2	66.3
99-C31/6	Inc. F86-C31/6, (C31/6)	26.0	25.7	2.0	4.3	5.0	3.8	3.8	6.0	80.4
R176-89	RZM R076-89	23.7	24.0	0.0	2.0	2.0	1.3	2.9	7.6	76.7
R176-89-18	RZM R076-89-18, (C76-89-18)	24.0	25.3	2.0	3.7	4.7	3.4	5.4	8.1	70.1
R176-89-5	RZM R076-89-5, (C76-89-5)	23.3	24.0	1.0	1.7	1.0	1.2	4.3	5.4	81.8
Y169	RZM-ER-% Y969, (C69)	26.7	26.0	2.0	3.3	3.3	2.9	2.7	5.9	84.6
Y190	RZM Y090	18.3	18.0	1.3	2.7	3.0	2.3	0.0	6.4	76.8
Y191	Inc. FS(C), C1, Syn 1	24.7	23.7	1.7	3.3	3.3	2.8	0.0	6.0	82.6
R021	RZM R926,R927, (C26,C27)	24.7	23.3	1.7	4.0	3.7	3.1	1.5	5.7	80.2
Y167	RZM-ER-% Y967, (C67/2)	26.7	27.0	1.7	3.0	3.7	2.8	1.2	6.6	79.5
Y171	RZM-ER-% Y971	24.3	24.7	2.7	5.0	5.3	4.3	1.5	6.6	77.1
Y175	RZM Y075	21.0	22.7	2.0	3.0	3.7	2.9	5.3	12.2	61.5
E740	Inc. E870, (susc. check)	23.0	25.0	3.7	4.7	4.7	4.3	20.3	51.4	19.0
US H11	1/3/99, (resistant check)	26.7	27.0	5.0	6.7	6.0	5.9	4.9	7.1	71.7
R136	RZM-ER-% R936, (C79-8)	25.0	24.7	3.7	5.0	4.7	4.4	1.4	3.2	81.0

TEST 5402. EVALUATION OF BREEDING LINES AND POPULATIONS FOR ERWINIA/POWDERY MILDEW, SALINAS, CA, 2002

(cont.)

Variety	Description	Harv. Count No.	Stand Count No.	Powdery Mildew Score 10/07	10/25	11/01	Mean	Root Rot %	Erwinia Root Rot DI	%Healthy
Multigerm, open-pollinated lines (cont.)										
R143	RZM-ER-% R943	25.0	25.3	2.3	3.0	2.3	2.6	4.0	7.0	73.5
R140	RZM-ER-% R940, R954	27.0	26.0	2.0	3.3	3.7	3.0	3.9	4.9	80.1
P007/8	PMR-RZM P807, P808	24.3	23.7	0.3	0.7	0.0	0.3	2.7	11.4	59.4
P127	PMR P027-#(C), P027B-#(C)	24.7	24.7	3.7	5.3	5.7	4.9	5.8	8.9	65.1
P128	PMR P028-#(C)	24.7	25.3	1.7	2.7	3.3	2.6	6.5	8.4	72.3
P129	PMR-RZM P029-#(C)	26.0	24.7	0.3	1.3	2.0	1.2	1.2	2.6	84.0
P130	PMR-RZM P030-#(C)	27.0	26.3	1.3	2.0	2.3	1.9	6.4	5.7	87.8
Multigerm, S^f, Aa populations										
N112	NR-RZM P912 (A,aa)	27.0	26.0	0.3	2.0	2.0	1.4	4.9	7.8	81.5
N172	NR-RZM N972 (A,aa)	26.0	25.3	1.3	3.0	3.3	2.6	5.3	12.4	66.8
N124	NR-RZM N024(galls)(A,aa)	26.7	25.7	1.0	1.7	2.3	1.7	2.4	12.0	65.1
1931(Sp)	RZM 0931aa x A, (popn-931)	24.0	23.7	1.3	2.7	3.0	2.3	4.0	4.9	77.5
1931(Iso)	RZM-ER-% 9931 (A,aa)	26.3	26.0	1.7	3.7	3.3	2.9	6.0	5.0	78.7
1941(Sp)	RZM 0941aa x A, (popn-941)	23.0	22.7	1.7	2.3	3.0	2.3	1.7	3.0	83.7
1941(Iso)	RZM-ER-% 9941 (A,aa)	25.3	25.3	1.7	2.7	3.3	2.6	2.6	3.2	83.2
Z125	RZM Z025aa x A, (popn-Z25)	25.7	25.7	1.7	3.7	4.0	3.1	1.4	12.5	71.5
CR111	RZM CR011aa x A, (popn-CR11)	23.3	21.7	3.3	5.0	5.0	4.4	1.6	4.7	80.0
1942	RZM 0942aa x A	25.3	24.0	1.0	3.0	3.0	2.3	0.0	2.9	80.8
1933	RZM-ER-% 9933 (A,aa)	26.7	26.7	2.0	3.0	3.0	2.7	2.5	4.1	87.6
1932	RZM-ER-% 9932 (A,aa)	24.3	24.0	1.7	3.0	3.3	2.7	1.4	6.3	87.6
US H11	11/3/99, (resistant check)	27.3	28.7	6.0	7.0	7.0	6.7	1.1	6.2	69.0
E740	Inc. E870, (susc. check)	24.7	24.3	3.7	5.3	5.0	4.7	16.7	49.5	23.1
1924	RZM-ER-% 9924 (A,aa)	25.3	25.3	1.3	2.7	3.0	2.3	4.0	8.4	79.2
01-FC1030	RZM 1999-1030,...aa x A	26.7	26.3	2.7	4.3	5.0	4.0	1.4	8.8	84.7
0747	Inc. 7747 (A,aa)	25.7	25.7	3.7	4.7	5.0	4.4	3.8	11.6	73.3

TEST 5402. EVALUATION OF BREEDING LINES AND POPULATIONS FOR ERWINIA/POWDERY MILDEW, SALINAS, CA, 2002

(cont.)

Variety	Description	Harv. Count No.	Stand Count No.	Powdery Mildew Score 10/07	10/25	11/01	Mean	Root Rot %	Erwinia Root Rot DI	Root Rot %Healthy
F₁ hybrids of 931 x C40										
1231 – 1	0831aa x E740	22.0	21.7	2.3	4.3	4.3	3.7	15.2	15.4	63.3
1232 – 1	E740(ms) x 0931	19.7	19.7	2.3	4.7	4.3	3.8	3.5	7.5	68.3
– 2	E740(ms) x 0931	18.3	17.7	4.0	5.0	5.3	4.8	4.2	20.2	45.1
– 3	E740(ms) x 0931	16.7	16.7	1.7	3.3	3.7	2.9	8.0	19.1	47.8
– 4	E740(ms) x 0931	20.7	19.0	1.0	2.0	3.3	2.1	3.4	9.9	72.2
– 5	E740(ms) x 0931	18.7	18.3	3.7	5.0	5.0	4.6	9.0	18.9	54.0
Monogerm populations & lines										
99-790-68	Inc. U88-7C790-68	26.7	27.3	0.3	1.3	1.3	1.0	11.0	29.6	49.9
00-790-15	Inc. F92-C790-15	27.0	26.7	1.0	1.7	2.0	1.6	3.6	9.0	72.1
1869	RZM 0869-#s(C)aa x A, (C869)	23.7	24.0	2.0	4.0	4.0	3.3	11.2	20.7	62.0
1835	RZM 0835(C)mmaa x A	24.0	23.3	2.3	3.0	3.0	2.8	4.3	18.6	55.6
1836	0836,0837mmaa x A	25.3	25.3	3.0	4.3	5.0	4.1	1.3	5.4	73.6
1842	RZM-ER-% 9840,…mmaa x A	21.3	22.3	2.0	4.0	4.3	3.4	6.1	22.1	61.2
1842HO(B)	0841HO,H5,…aa x A	25.3	25.0	2.0	3.3	3.3	2.9	6.6	14.2	65.8
0841H7	9833-5aa x 841(C)	25.3	25.3	1.0	1.7	2.3	1.7	0.0	12.6	69.9
1848M	RZM-ER-% 9818,0848(A,aa)	25.0	25.7	0.3	2.0	1.7	1.3	5.2	11.9	79.1
0833-5A(Sp)	Inc. 0833-5(T-O)A	25.0	23.3	0.0	1.7	1.7	1.1	4.5	7.6	86.3
0833-5HO(Sp)	RZM 9833-5(T-O)HO x 9833-5(T-O)	25.0	24.7	0.3	2.3	2.3	1.7	2.6	8.7	77.4
E740	Inc. E870, (susc. check)	23.3	23.3	4.3	5.0	5.0	4.8	12.2	55.3	22.7
US H11	11/3/99, (resistant check)	28.7	28.0	6.0	7.0	6.7	6.6	4.8	8.4	69.7
01-FC123	RZM 00-FC123mmaa x A	22.3	22.0	2.0	3.3	3.7	3.0	3.5	20.1	56.3
01-FC1014	RZM 00-FC1014mmaa x A	26.0	24.7	0.7	3.0	3.7	2.4	11.9	20.8	66.9

A152

TEST 5402. EVALUATION OF BREEDING LINES AND POPULATIONS FOR ERWINIA/POWDERY MILDEW, SALINAS, CA, 2002

(cont.)

Variety	Description	Harv. Count No.	Stand Count No.	Powdery Mildew Score 10/07	10/25	11/01	Mean	Root Rot %	Erwinia Root Rot DI	%Healthy
Monogerm populations & lines (cont.)										
1833-5(Iso)	RZM0833-5(Sp)(A,aa),(C833-5)	26.7	25.0	0.7	2.0	2.0	1.6	1.3	2.7	91.2
1833-5HO(Iso)	RZM 0833-5HO x " " ,(C833-5CMS)	24.3	24.0	0.3	2.7	2.7	1.9	2.8	8.9	81.0
1833-5	Inc. 0833-5(Sp)(A,aa),(C833-5)	25.7	24.3	0.0	2.3	2.7	1.7	4.1	8.2	79.8
1833-5-8	Inc. 8833-5-8 (A,aa)	24.3	24.3	0.3	1.3	2.0	1.2	1.4	4.1	84.0
1833-5-11	Inc. 8833-5-11 (A,aa)	24.0	23.3	0.0	1.7	2.0	1.2	1.4	0.9	97.3
1835-11	Inc. 8835-11 (A,aa)	27.3	24.3	0.0	1.0	0.7	0.6	0.0	8.4	80.5
1835-26	Inc. 8835-26 (A,aa)	23.0	22.7	0.7	2.3	3.3	2.1	14.0	36.0	40.6
N165-9M	Inc. N065-9 (A,aa)	19.7	25.3	0.3	2.0	2.3	1.6	10.4	38.6	26.6
N165	NR-RZM N065mm (galls)(A,aa)	24.7	26.3	0.3	2.0	2.7	1.7	6.5	33.9	31.3
N167M	Inc.N067-1(C),N066-1(galls)(A,aa)	24.7	25.0	0.3	2.7	2.7	1.9	4.0	12.9	53.9
Mean		24.6	24.4	2.1	3.5	3.7	3.1	4.9	12.6	68.3
LSD (.05)		3.9	3.1	1.6	1.5	1.5	1.3	6.9	9.1	17.5
C.V. (%)		9.9	8.0	48.1	25.8	24.7	25.7	87.5	44.6	15.9
F value		2.7**	4.1**	7.7**	9.1**	8.1**	11.1**	2.9**	12.5**	7.6**

A153

TEST 5502. ERWINIA/POWDERY MILDEW EVALUATION OF POPULATIONS & PROGENY LINES, SALINAS, CA, 2002

60 entries x 3 reps, sequential
1-row plots, 17.5 ft. long

Planted: March 25, 2002
Not harvested for yield

Variety	Description	Harv. Count No.	Stand Count No.	Powdery Mildew Score 10/07	10/25	11/01	Mean	Erwinia Root Rot DI	%Healthy
E740	Inc. E840 (susc. check)	23.7	23.0	3.3	5.0	4.7	4.3	57.6	14.9
US H11	9/3/99 (resistant check)	27.3	27.7	5.0	7.0	6.0	6.0	6.7	73.1
1931	RZM 0931aa x A	25.7	26.0	2.3	4.0	3.7	3.3	3.8	84.9
1941	RZM 0941aa x A	25.0	24.3	1.3	3.0	3.7	2.7	6.0	88.1
Z125	RZM Z025aa x A	25.7	24.7	2.0	3.7	4.0	3.2	7.0	77.7
CR111	RZM CR011	22.7	23.0	2.7	4.7	5.3	4.2	8.5	74.7
R178	RZM-ER-% R978, (C78/3)	27.0	26.3	1.0	4.3	4.7	3.3	9.6	82.9
Y190	Inc. Y090	21.0	20.0	2.0	4.3	4.7	3.7	6.3	88.9
Y191	Inc. FS(C),Cl,Syn 1	26.7	27.0	1.3	4.3	4.7	3.4	7.2	86.4
0930-19	8930-19aa x A	28.3	28.0	0.0	2.0	1.7	1.2	7.8	81.2
1930-19	NB 8930-19(A,aa), (C930-19)	25.0	25.7	0.0	1.3	1.7	1.0	6.3	77.9
1930-35A	RZM 9930-35A, (C930-35)	22.3	24.0	0.3	2.7	2.7	1.9	29.9	34.3
1929-62	RZM 9929-62aa x A, (C929-62)	25.0	25.3	0.3	2.0	2.3	1.6	10.5	71.9
1927-4	RZM 9927-4aa x A, (C927-4)	29.0	27.0	3.0	5.0	4.7	4.2	2.3	87.3
1929-4	RZM 9929-4aa x A	27.3	26.0	1.0	2.3	2.3	1.9	2.4	94.2
1924-2	RZM 9924-2aa x A	23.3	24.7	0.7	3.0	2.3	2.0	7.1	81.7
1935-6	Inc. 9935-6 (A,aa)	25.0	24.7	0.0	0.7	1.0	0.6	3.0	93.2
9929-45	Inc. 7929-45VY	20.7	22.7	1.7	2.7	2.7	2.3	13.3	67.3
0929-112	8929-112aa x A	25.3	25.0	1.7	3.3	3.0	2.7	0.7	97.3
R176-89-5	RZM R076-89-5, (C76-89-5)	24.0	23.3	0.7	2.7	2.0	1.8	3.4	91.7
R176-89-5-13	Inc. R976-89-5-13	27.0	26.7	0.7	2.7	2.7	2.0	2.4	96.3
R176-89-18	RZM R076-89-18	25.3	25.7	2.7	4.7	5.0	4.1	9.8	75.0
E740	Inc. E840 (susc. check)	26.7	26.3	5.0	6.3	6.0	5.8	52.2	22.7
US H11	9/3/99 (resistant check)	28.0	29.3	5.3	7.7	6.7	6.6	8.7	74.8
Z025-9	Z825-9aa x A, (CZ25-9)	28.7	25.7	1.7	2.0	2.0	1.9	12.7	68.8
Z131-20	Inc. Z931-20 (A,aa)	25.0	25.3	0.7	1.3	1.3	1.1	14.5	68.1
Z131-14	Inc. Z931-14 (A,aa)	25.0	25.3	1.0	2.7	2.7	2.1	22.8	48.0
Z131-18	Inc. Z931-18 (A,aa)	28.0	28.3	0.3	1.7	1.3	1.1	2.1	95.4

(cont.)

Variety	Description	Harv. Count No.	Stand Count No.	Powdery Mildew Score 10/07	10/25	11/01	Mean	Erwinia Root Rot DI	%Healthy
CR009-1	CR009-1aa x A, (CR09-1)	25.3	25.7	2.7	4.0	5.0	3.9	8.6	85.5
CR110-14-2	Inc. CR910-14-2 (A,aa)	24.3	25.0	0.7	1.7	2.0	1.4	1.7	93.2
CR110-5	Inc. CR910-5 (A,aa)	20.7	21.7	0.7	2.3	2.3	1.8	23.9	53.6
CR112-5	Inc. CR812-5 (A,aa)	25.7	28.0	3.3	5.3	5.3	4.7	34.4	48.9
1936-14	Inc. 9936-14 (A,aa)	26.7	25.7	1.7	3.0	3.0	2.6	23.7	63.0
1931-56	Inc. 9931-56 (A,aa)	27.7	27.3	0.0	0.3	1.7	0.7	6.2	79.3
1931-201	Inc. 9931-201 (A,aa)	26.3	27.0	0.3	0.7	1.3	0.8	13.9	67.0
0934-5	Inc. 8934-5 (A,aa)	26.7	27.0	3.3	5.0	5.3	4.6	10.2	83.9
0936-8	Inc. 8936-8 (A,aa)	25.0	25.3	0.0	1.0	0.3	0.4	0.8	98.6
0936-10	Inc. 8936-10 (A,aa)	28.0	27.0	0.7	2.3	3.3	2.1	6.0	88.1
0936-16	Inc. 8936-16 (A,aa)	25.3	25.3	0.3	1.0	0.7	0.7	7.3	77.7
R078-4	Inc. R878-4	27.7	28.0	0.3	2.3	3.0	1.9	6.2	83.4
R080/2-9	Inc. R880/2-4	23.7	24.0	4.0	5.3	5.7	5.0	1.6	88.8
R178-5	Inc. R978-5	27.7	27.0	1.3	4.3	4.3	3.3	16.0	72.5
R178-6	Inc. R978-6	26.0	25.0	3.0	4.7	4.3	4.0	12.7	67.8
R178-11	Inc. R978-11	25.7	25.7	0.7	3.7	4.0	2.8	11.7	75.5
E740	Inc. E840 (susc. check)	24.7	24.3	4.7	5.3	5.7	5.2	58.0	15.3
US H11	9/3/99 (resistant check)	27.3	27.7	5.3	6.7	6.3	6.1	8.0	78.1
R180-11	Inc. R980-11	23.7	23.3	3.7	5.3	5.3	4.8	3.0	94.1
R180-16	Inc. R980-16	26.3	27.3	3.3	5.0	5.3	4.6	5.0	93.8
R180-21	Inc. R980-21	25.0	25.7	1.3	3.3	3.7	2.8	6.9	86.3
R168-8	Inc. Y968-8	24.0	24.7	1.7	2.7	3.3	2.6	7.0	83.1
Y168-13	Inc. Y968-13	25.7	27.0	0.7	3.0	3.7	2.4	6.7	86.3
Y168-16	Inc. Y968-16	24.7	25.0	0.0	1.3	2.3	1.2	0.3	100.0
Y167-5	Inc. Y967-5	26.3	26.3	0.3	2.3	3.0	1.9	12.3	78.7
Y172-1	Inc. Y972-1	25.7	27.3	1.7	4.0	4.7	3.4	13.5	71.0

TEST 5502. ERWINIA/POWDERY MILDEW EVALUATION OF POPULATIONS & PROGENY LINES, SALINAS, CA, 2002

(cont.)

Variety	Description	Harv. Count No.	Stand Count No.	Powdery Mildew Score				Erwinia Root Rot	
				10/07	10/25	11/01	Mean	DI	%Healthy
Y172-5	Inc. Y972-5	25.7	25.7	2.7	4.7	5.0	4.1	9.5	75.2
Y172-7	Inc. Y972-7	26.0	27.3	2.7	5.0	5.7	4.4	10.1	72.2
Y175-13	Inc. Y975-13	26.3	25.7	3.3	4.7	5.3	4.4	21.3	69.6
R181-22	Inc. R981-22	24.7	25.0	1.3	3.0	3.3	2.6	7.5	90.5
R176-89-5-4	Inc. R976-89-5-4	26.3	26.0	0.3	1.3	1.3	1.0	1.3	97.4
R176-89-5NB-4	Inc. R976-89-5NB-5	28.7	27.3	0.0	0.7	0.0	0.2	6.8	87.7
Mean		25.6	25.7	1.7	3.4	3.5	2.9	11.5	76.8
LSD (.05)		4.0	3.0	1.5	1.5	1.2	1.1	9.7	15.5
C.V. (%)		9.8	7.3	54.3	27.4	21.1	24.3	52.4	12.5
F value		1.7**	2.5**	7.8**	10.3**	15.2**	15.5**	12.9**	11.7**

A156

64 entries x 3 reps, sequential
1-row plots, 11 ft. long

Planted: April 22, 2002
Not harvested for yield

Variety	Description	Stand Count No.	Bolting %	10/25	Powdery Mildew 11/04	11/14	Mean
Checks							
N124	NR-RZM N024(g)(A,aa)	16.7	0.0	5.0	4.7	4.7	4.8
N172	NR-RZM N972 (A,aa)	17.3	0.0	4.7	4.7	3.7	4.3
N112	NR-RZM P912 (A,aa)	18.7	0.0	4.3	4.3	3.7	4.1
P007/8	PMR-RZM P807-2,-8	18.7	0.0	3.7	3.3	3.0	3.3
01-C37	Inc. U86-37, (C37)	19.3	0.0	8.3	7.3	6.7	7.4
R178	RZM-ER-% R978	19.0	0.0	6.0	5.7	6.0	5.9
P129	PMR-RZM P029-#(C)	17.3	0.0	5.3	4.0	4.3	4.6
P130	PMR-RZM P030-#(C)	16.3	0.0	5.3	4.7	5.3	5.1
PMR progenies (see tests 1102 & 4802)							
P121-6-1	P921-6(PX),(C78 x P811)	13.3	0.0	6.3	5.3	6.0	5.9
P121-6-2		14.7	13.5	2.7	2.3	2.7	2.6
P121-6-3		13.0	30.7	5.3	5.0	5.7	5.3
P121-6-4		11.7	24.6	4.7	4.0	3.7	4.1
P121-6-5		13.3	0.0	4.3	4.7	4.0	4.3
P121-6-6		15.3	47.6	3.3	4.0	3.7	3.7
P121-6-7		15.3	0.0	5.0	5.0	4.3	4.8
P121-6-8		15.0	20.4	3.7	4.7	4.3	4.2
P121-6-9		16.0	26.8	5.7	5.3	5.3	5.4
P121-6-10		14.0	18.9	3.0	3.0	2.3	2.8
P118-8-1	P118-8(PX),(C37 x P816)	15.3	0.0	4.3	4.0	4.0	4.1
P118-8-2		15.3	0.0	3.0	3.0	2.7	2.9
P118-8-3		14.3	0.0	2.3	2.3	2.3	2.3
P118-8-4		13.7	0.0	3.0	3.0	2.3	2.8
P118-8-5		13.7	0.0	3.3	2.7	2.7	2.9
P118-8-6		15.0	0.0	5.3	5.3	4.7	5.1
P118-8-7		12.0	0.0	5.0	4.3	4.3	4.6
P118-8-8		12.3	0.0	2.7	3.0	3.0	2.9
P118-6	Inc. P918-6	16.0	0.0	4.7	4.7	4.3	4.6
P125-12	Inc. P925-12	15.7	0.0	5.3	5.0	5.0	5.1
NR-PMR-RZM S_1 progenies (see test 1102)							
N112-1	NR-RZM P912⊗	11.0	0.0	1.3	1.0	1.7	1.3
N112-2		12.7	0.0	2.0	1.0	1.0	1.3
N112-3		14.3	0.0	6.0	5.7	5.7	5.8
N112-4		7.7	0.0	1.7	1.0	1.3	1.3
N112-5		12.3	0.0	6.0	6.7	6.0	6.2
N112-6		11.7	13.2	2.3	1.7	2.3	2.1
NR-RZM S_1 progenies (see test 1102)							
N172-1	NR-RZM N972⊗	13.3	0.0	4.0	3.3	3.7	3.7
N172-2		10.3	0.0	6.0	5.7	6.7	6.1

A157

(cont.)

Variety	Description	Stand Count No.	Bolting %	Powdery Mildew 10/25	11/04	11/14	Mean
RZM resistance under high temps from *Bvm*							
S_2's from 9934-8 = RZM 7934⊗ (see test 1102)							
1934-8-1	9934-8⊗	10.0	0.0	7.0	6.0	5.7	6.2
1934-8-2		11.7	0.0	6.3	5.3	5.3	5.7
1934-8-3		12.3	0.0	8.3	7.7	7.0	7.7
1934-8-4		14.3	0.0	8.7	7.7	7.0	7.8
S_2's from 9926-11 = RZM 8926⊗ (see test 1102)							
1926-11-1	9926-11⊗	11.0	0.0	4.3	3.0	3.3	3.6
1926-11-2		9.3	0.0	4.7	4.3	4.7	4.6
1926-11-3		13.3	0.0	5.3	4.7	5.3	5.1
1926-11-4		13.3	0.0	5.3	5.0	5.3	5.2
S_2's from 9926-15 = RZM 8926⊗ (see test 1102)							
1926-15-1	9926-15⊗	12.0	0.0	4.0	4.0	4.0	4.0
1926-15-2		12.3	0.0	5.3	5.0	4.3	4.9
1926-15-3		9.0	0.0	4.7	4.3	4.0	4.3
1926-15-4		11.0	0.0	5.0	5.0	4.7	4.9
Nematode resistant progenies							
NR S_1 progenies from N024(g)							
N124-1	RZM N024(g)⊗	12.3	0.0	4.0	4.0	4.0	4.0
N124-2		11.3	0.0	2.7	2.0	2.0	2.2
N124-3		11.7	0.0	5.0	4.7	4.3	4.7
N124-4		11.3	0.0	4.0	3.0	2.7	3.2
N130-5-1	RZM N030-5NN(g)⊗	10.3	0.0	4.7	4.3	4.3	4.4
NR monogerm lines							
N165	NR-RZM N065mm(g)(A,aa)	18.3	0.0	4.7	4.3	4.0	4.3
N167	Inc. N067-#(C)(g)(A,aa)	18.0	0.0	4.3	3.7	3.3	3.8
N165-9	Inc. N065-9(A,aa)mm	15.0	0.0	3.7	3.0	2.3	3.0
NR S_1 progenies from N065							
N165-1	N065m(g)mm⊗	11.0	0.0	5.0	4.7	4.7	4.8
N165-2	no plants						
N165-3		12.3	0.0	2.3	2.0	2.7	2.3
N165-4		14.7	0.0	1.7	1.3	1.3	1.4
N165-5		15.3	0.0	3.0	3.3	2.3	2.9
N165-6		14.0	0.0	3.7	4.0	3.3	3.7
N165-7		10.7	0.0	3.7	2.7	2.3	2.9
N165-8	no plants						
Mean		13.7	3.2	4.5	4.1	4.0	4.2
LSD (.05)		2.8	8.4	1.5	1.3	1.3	1.1
C.V. (%)		12.7	164.2	20.2	19.1	20.0	16.6
F value		6.9**	9.2**	9.1**	11.2**	10.1**	13.9**

TEST 6802. RHIZOMANIA EVALUATION OF POWDERY MILDEW RESISTANT LINES & POPULATIONS, SALINAS, CA, 2002

32 entries x 6 reps., RCB
1-row plots, 11 ft. long

Planted: April 22, 2002
Harvested: November 26, 2002

| | | Acre Yield | | | Beets/ | | | | Root | Powdery |
| | | Sugar | Beets | Sucrose | 100' | RJAP | Bolting | | Rot | Mildew |
Variety	Description	Lbs	Tons	%	No.	%	%		%	Mean
US H11	11/3/99 (rhizom.,PM susc.check)	8990	30.21	14.88	153	86.2	0.0		5.2	7.7
R039	Inc. R539 (C39R) (Quantitative PMR)	13207	40.18	16.42	158	86.0	0.0		4.9	4.2
P601	PMR P401 (WB97 & WB242)	12590	37.76	16.65	145	84.9	4.5		2.4	4.3
8918-12	RZM-ER-% 6918-12 (Quantitative PMR)	12605	36.69	17.20	138	84.4	0.0		5.6	1.8
R178	RZM-ER-% R978 (Rz recurrent parent)	13653	38.03	18.07	164	87.9	0.0		0.0	6.1
01-C37	Inc. U86-C37 (rzrz recurrent parent)	9173	29.12	15.80	162	87.1	0.0		9.3	7.4
P129	PMR-RZM P029-#(C), (C78 x WB97)	13951	39.45	17.70	150	85.4	0.0		3.3	4.6
P130	PMR-RZM P030-#(C), (C78 x WB242)	14746	43.04	17.17	147	84.4	0.0		9.1	4.3
P019	PMR-RZM P919-#,B-#(C),(C78 x WB97)	14117	39.36	17.90	148	88.4	0.0		9.9	4.4
P020	PMR-RZM P920-#,B-#(C),(C78 x WB242)	13488	39.39	17.10	152	87.2	9.0		11.8	4.6
N112	NR-RZM P912(A,aa),(915aa x P402,NR)	13396	39.83	16.80	153	85.1	0.0		2.3	4.2
P912	PMR-RZM P812, (915aa x P402)	13018	38.70	16.77	153	85.8	0.0		3.9	4.2
P017	PMR-RZM P917-#(C),B-#(C),(C37 x WB97)	11430	35.21	16.28	156	86.1	11.4		5.9	5.7
P018	PMR-RZM P918-#(C),B-#(C),(C37 x WB242)	13168	39.59	16.60	156	85.0	7.9		2.8	4.9
P127	PMR P027-#,B-#(C),(C37 x WB97)	10180	31.04	16.35	158	87.6	6.7		1.0	6.7
P128	PMR P028-#,B-#(C),(C37 x WB242)	13994	41.39	16.92	159	84.5	0.0		7.2	4.7
01-C37	Inc. U86-C37 (rzrz recurrent parent)	9559	29.70	16.18	167	85.6	0.0		4.6	7.6
R178	RZM-ER-% R978 (Rz recurrent parent)	13258	36.96	17.97	161	85.7	0.0		2.7	5.2
R118-6	Inc. P918-6,[C37x(C78 x P604)],WB242	12425	36.55	17.02	161	83.6	0.0		0.0	4.6
P125-12	Inc. P925-12,[C78x(C78 x P603)],WB97	11682	32.52	17.97	152	85.6	0.0		7.3	5.4
P129H50	C790-15CMS x PMR-RZM P029-#(C)	13765	39.91	17.23	158	86.4	2.9		4.7	5.7
P130H50	C790-15CMS x PMR-RZM P030-#(C)	15119	44.03	17.22	156	86.7	0.0		2.1	4.8
P012	PMR-RZM P912, (915aa x P402,NR)	12560	39.78	15.78	141	84.7	3.0		2.2	4.3
P007/8	PMR-RZM P807-2; -8; P808-7,-8	13857	40.31	17.20	153	84.8	0.0		7.7	2.8

TEST 6802. RHIZOMANIA EVALUATION OF POWDERY MILDEW RESISTANT LINES & POPULATIONS, SALINAS, CA, 2002

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Bolting %	Root Rot %	Powdery Mildew Mean
P007	PMR-RZM P907, [C78 x (Y71 x P603,4)]	12579	38.03	16.53	150	83.8	0.0	4.9	5.0
US H11	11/3/99 (rhizom., PM susc. check)	8941	29.46	15.12	147	86.7	0.0	1.0	7.8
P913	PMR P813, CP01, WB97 source	11183	34.03	16.43	144	84.8	4.2	0.0	4.6
P914	PMR P814, CP02, WB242 source	10471	33.06	15.90	148	85.6	7.5	3.1	5.3
R021	RZM R926,R927,(C26,C27)	11872	35.58	16.67	150	87.0	0.0	0.0	5.8
Y191	Inc. FS(C), C1, Syn 1	13229	36.96	17.88	156	85.8	0.0	1.1	5.0
1930-19	NB 8930-19(A,aa), (C930-19)	12943	39.11	16.57	158	86.3	0.0	2.1	4.8
1929-62	RZM 9929-62aa x A, (C929-62)	12712	37.04	17.05	150	85.1	0.0	1.9	3.2
Mean		12433.2	36.94	16.79	153.2	85.8	1.8	4.1	5.1
LSD (.05)		1982.6	5.47	0.85	14.6	2.6	3.2	9.1	0.7
C.V. (%)		14.0	12.99	4.44	8.4	2.6	156.7	196.5	12.9
F value		5.5**	4.11**	6.69**	1.6*	1.6*	8.1**	0.9NS	25.5**

Powdery mildew scored on 10/25/02, 11/4/02, & 11/14/02 on a scale of 0 to 9, where 9 = 90-100% of mature leaf area covered with PM. P#'s at best segregate for high resistance to PM.

Root rot was caused by *Sclerotium rolfsii*. At harvest all roots were weighed, but beets with rot were excluded from sugar sample.

TEST 5302. EVALUATION OF BREEDING LINES AND POPULATIONS FOR ERWINIA/POWDERY MILDEW, SALINAS, CA, 2002

40 entries x 3 reps., sequential
1-row plots, 17.5 ft. long

Planted: March 25, 2002
Not harvested for yield

Variety	Description	Harv. Count No.	Stand Count No.	Powdery Mildew Score	Erwinia Root Rot DI	%Healthy
US H11	9/3/99 (resist check)	24.0	27.3	5.7	13.4	0.6
E740	Inc. E840 (susc. check)	22.0	26.0	3.3	60.4	0.1
Beta 4001R	9/25/01	28.3	28.7	2.0	18.7	0.6
Phoenix	8/16/01	26.7	27.7	4.0	9.8	0.7
Beta 4776R	2/5/02	24.3	26.3	2.7	8.0	0.8
HH141	8/16/01	23.0	26.0	3.3	24.0	0.6
Beta 4430R	8/31/01	25.3	26.3	0.7	8.2	0.7
Rizor	3/29/01	24.3	25.7	3.0	7.0	0.8
Beta 4035R	2/5/02	25.7	27.3	3.3	20.3	0.6
Beta 6600	2/5/02	24.7	25.3	2.7	10.3	0.8
Crystal 205	2/22/02	25.7	27.3	4.3	4.9	0.8
Angelina	2/19/02	26.3	26.3	6.3	14.6	0.6
Dorotea	3/21/02	25.0	26.3	2.0	6.4	0.8
HM-E17	3/21/02	26.3	27.3	4.7	16.8	0.7
E740	Inc. E840 (susc. check)	21.7	24.3	3.0	44.8	0.2
Y190H50	C790-15CMS x Y090	20.3	22.0	2.3	12.1	0.7
Y190H5	0833-5HO x Y090	15.7	15.7	0.7	12.5	0.6
Y190H6	0833-5H50 x Y090	17.7	19.3	2.3	7.8	0.7
Y190H45	9867-1HO x Y090	15.3	17.3	2.0	13.0	0.7
Y190H2	9831-3HO x Y090	18.0	17.0	2.0	15.1	0.5
Y190H27	9831-4HO x Y090	20.0	18.7	2.0	15.3	0.6
Y190H29	0831-4-10HO x Y090	22.0	22.0	3.0	15.0	0.7
Y190H7	0833-5aa x Y090	18.7	18.7	2.0	7.6	0.8
Y190H62	0836-1H5 x Y090	16.3	16.3	2.0	8.2	0.7

TEST 5302. EVALUATION OF BREEDING LINES AND POPULATIONS FOR ERWINIA/POWDERY MILDEW, SALINAS, CA, 2002

(cont.)

Variety	Description		Harv. Count No.	Stand Count No.	Powdery Mildew Score	Erwinia Root Rot DI	%Healthy
Y190H63	0836-7H5	x Y090	17.3	19.0	1.7	8.9	0.7
Y190H64	0834-2H5	x Y090	17.7	18.3	2.7	17.1	0.6
US H11	9/3/99 (resist check)		25.7	29.0	6.7	7.9	0.7
E740	Inc. E840 (susc. check)		21.7	23.7	4.0	55.7	0.1
Y190H67	0837-6H5	x Y090	19.0	19.3	3.3	20.9	0.6
Y190H82	0833-5H2	x Y090	18.3	18.3	2.7	13.6	0.7
Y190H83	0833-5H27	x Y090	17.0	18.7	1.0	12.7	0.6
Y190H84	0833-5H45	x Y090	18.0	20.7	2.3	16.1	0.7
Y190H85	0833-5H46	x Y090	20.0	19.3	3.3	4.8	0.8
Y190H3	97-C562HO	x Y090	19.7	19.7	3.3	12.3	0.7
Y190H46	9869-6HO	x Y090	20.3	21.3	5.3	8.5	0.8
Y190H28	0831-4-7HO	x Y090	17.7	18.0	3.7	23.1	0.5
Y190H11	CR011aa	x Y090	21.7	22.7	4.0	1.1	0.9
Y190H25	Z025aa	x Y090	23.0	24.0	3.0	9.9	0.7
Y190H31	0931aa	x Y090	24.3	24.0	3.0	7.4	0.8
Y190H41	0941aa	x Y090	20.3	21.3	2.7	9.4	0.8
Mean			21.5	22.6	3.1	15.1	0.7
LSD (.05)			4.4	3.9	1.8	9.4	0.2
C.V. (%)			12.6	10.6	35.3	38.3	14.8
F value			5.1**	8.2**	4.7**	13.7**	9.7**

A162

TEST 5102. CODED POWDERY MILDEW TEST, SALINAS, CA, 2002

32 entries x 6 reps, sequential
1-row plots, 11 ft. long

Planted: March 25, 2002
Not harvested for yield

Code No.	Variety	Stand Count No.	Powdery Mildew Score										Mean
			8/01	8/15	8/23	9/05	9/13	9/20	9/27	10/4	10/11	10/25	
USDA checks													
	P130	14.5	0.0	0.2	1.0	0.8	2.0	2.0	2.8	3.2	3.5	4.2	2.0
	US H11	16.2	1.3	3.0	4.3	5.3	5.5	5.8	6.3	6.3	7.0	6.3	5.1
Coded entries													
PM- 1	Acclaim	16.5	2.5	3.8	4.5	4.3	3.8	4.0	4.5	5.0	5.2	5.7	4.3
- 2	00HX016	15.5	3.0	4.2	5.2	4.7	4.2	4.5	4.7	5.0	5.5	5.8	4.7
- 3	7KJ0191	16.5	3.8	5.3	6.2	6.0	5.8	5.8	6.2	5.8	6.5	5.7	5.7
- 4	01HX002	16.5	4.2	5.2	5.7	4.7	4.7	4.8	5.0	5.3	6.3	5.5	5.1
- 5	HH 145	15.2	1.7	3.8	3.8	4.3	4.5	4.7	5.0	5.0	5.5	5.2	4.3
- 6	00HX051	16.8	0.7	1.7	2.8	3.5	3.8	3.7	4.3	4.3	4.5	4.7	3.4
- 7	9GK7014	16.0	0.2	1.7	1.7	1.2	2.2	2.2	2.8	3.5	3.3	3.5	2.2
- 8	Eagle	16.2	1.2	3.0	3.2	3.7	3.8	4.2	4.5	5.3	5.8	5.5	4.0
- 9	US H11	17.2	1.7	3.8	4.0	4.8	5.2	5.5	6.3	6.5	6.5	6.8	5.1
-10	Crystal R062	17.0	0.3	1.7	2.5	2.8	3.3	3.2	3.2	3.3	3.0	2.7	2.6
-11	00HX052	16.8	1.0	2.3	3.5	3.7	3.2	3.3	3.8	4.0	4.0	4.5	3.3
-12	Phoenix	16.3	1.5	2.3	2.8	3.0	3.2	3.7	4.3	4.7	5.0	5.2	3.6
-13	Beta 4175R	17.0	1.7	3.7	3.7	3.8	4.2	4.7	5.5	5.8	6.5	6.3	4.6
-14	9GK7003	15.8	0.5	0.8	1.2	1.2	1.7	2.2	2.8	3.7	3.2	4.3	2.2
-15	01HX004	16.2	1.3	2.2	3.2	3.5	3.3	3.8	4.2	4.5	4.7	4.5	3.5
-16	US H11	17.0	1.7	3.3	3.8	5.7	6.0	6.5	7.3	7.2	7.3	7.3	5.6
-17	US H11	16.7	1.2	3.3	3.7	5.5	6.0	6.3	6.8	6.8	7.0	6.7	5.3
-18	HH 142	14.7	0.3	1.5	2.5	2.7	3.3	2.8	3.7	3.8	3.8	4.7	2.9

A163

TEST 5102.   CODED POWDERY MILDEW TEST, SALINAS, CA, 2002

(cont.)

Code No.	Variety	Stand Count No.	Powdery Mildew Score										
			8/01	8/15	8/23	9/05	9/13	9/20	9/27	10/4	10/11	10/25	Mean
Coded entries (cont.)													
PM-19	9GK1596	16.8	1.0	2.8	3.0	2.0	2.5	2.3	3.5	3.7	3.7	4.5	2.9
-20	00HX056	16.2	2.7	3.8	4.0	4.0	4.2	4.3	4.8	5.3	5.7	6.8	4.6
-21	Crystal R061	15.5	1.7	3.3	3.3	3.2	3.3	4.0	4.3	4.3	4.7	5.2	3.7
-22	HH 141	15.7	1.5	2.8	3.7	4.3	3.8	4.3	5.3	5.2	5.3	5.7	4.2
-23	Beta 4001R	16.3	0.3	1.2	1.5	1.3	2.2	2.2	3.2	3.2	3.5	3.8	2.2
-24	US H11	16.7	2.0	3.0	3.7	5.3	5.5	6.0	7.2	6.7	7.3	7.2	5.4
-25	Beta 4440R	17.2	3.2	4.2	3.5	3.5	3.8	5.0	5.5	6.0	6.7	7.0	4.8
-26	9J0158	16.8	1.3	2.8	3.8	4.3	4.3	4.3	4.8	5.2	5.3	5.2	4.2
-27	Beta 4200R	16.2	0.5	1.7	2.7	2.5	2.8	2.8	3.3	3.3	3.3	3.7	2.7
-28	99HX981	16.5	2.0	3.7	3.2	3.0	3.5	3.5	4.5	4.5	4.7	4.7	3.7
-29	9GK1701	16.3	0.7	2.2	2.7	3.5	4.0	4.0	4.2	4.5	4.8	5.0	3.5
-30	9BK1705	16.3	0.5	1.7	2.3	2.2	2.7	3.3	4.0	4.7	5.0	5.2	3.2
Mean		16.3	1.5	2.4	3.3	3.6	3.8	4.1	4.7	4.9	5.1	5.3	3.9
LSD (.05)		1.3	1.1	1.3	1.2	1.3	1.1	1.1	1.0	0.9	1.0	0.9	0.8
C.V. (%)		7.1	66.4	46.2	31.2	31.9	25.2	24.2	18.4	16.7	17.7	15.5	18.0
F value		2.0**	6.9**	6.2**	7.5**	8.8**	8.8**	9.9**	12.9**	11.6**	12.7**	11.8**	14.7**

Notes: Scored by J.A. Orozco on a scale of 0 to 9, where 9 = highly susceptible (90-100% of visible leaf area covered with mildew).

Powdery mildew development was moderate in 2002. Test did not appear to have rhizomania or other severe diseases. Light to moderate infection occurred for downy mildew and rust.

Planted: November 7, 2001

Not harvested for yield

100 entries x 3 reps., sequential
2001
1-row plots, 17.5 ft. long

Variety	Description	Stand Count No.	% Bolting 6/29	8/05	9/04	Emerg Score	Downey Mildew 4/05	5/23	Root Rot %	7/25	Powdery Mildew 8/08	8/23	Mean
Checks													
Beta 4776R	Betaseed, 8-31-01	30.0	0.0	13.7	22.3	2	1.7	1.7	0.0	4.7	6.3	7.3	6.1
Beta 4430R	Betaseed, 8-31-01	29.7	5.5	22.6	30.4	2	4.7	3.0	0.0	5.3	5.3	6.0	5.6
HH141	Holly, 8-16-01	24.7	0.0	5.3	9.4	3	2.7	0.3	1.3	4.7	6.7	7.0	6.1
Phoenix	Holly, 8-16-01	27.0	9.9	38.3	45.7	3	2.0	2.3	0.0	5.0	7.3	7.0	6.4
Monohikari	Seedex, 4-18-01	27.7	69.8	90.2	93.4	2	1.7	2.0	0.0	6.0	7.7	7.0	6.9
US H11	11-3-99	25.3	0.0	1.3	1.3	2	1.7	0.3	0.0	6.3	8.0	8.7	7.7
Beta 4001R	Betaseed, 9-25-01	27.0	0.0	9.8	12.2	2	2.7	1.7	0.0	4.7	7.0	8.0	6.6
SS-NB3	Spreckels, 4-96	28.3	2.4	3.6	7.1	2	4.0	0.7	0.0	5.3	8.0	9.0	7.4
E17	Michigan Sugar Co,3-27-01	26.3	76.9	81.6	88.5	3	0.7	0.3	5.1	6.3	8.3	8.0	7.6
Rizor	Holly, 3-29-01	29.3	13.6	37.5	51.3	2	3.7	2.0	0.0	5.3	8.0	8.7	7.3
Hybrids with C833-5													
Y190H5	0833-5HO x Y090	16.0	6.7	13.3	13.3	4	0.3	0.0	5.3	4.3	6.7	7.3	6.1
Y190H5(Iso)	0833-5HO(Iso) x Y090	12.3	2.0	12.5	15.9	4	2.0	1.3	10.0	4.7	6.7	7.3	6.2
Y175H5	0833-5HO x Y75(C)	25.0	2.5	13.2	13.2	3	5.0	1.7	2.5	3.7	6.3	6.7	5.6
R176-89H5	0833-5HO x RZM R076-89	26.0	12.1	19.6	20.9	3	2.0	0.7	0.0	4.3	6.3	7.0	5.9
1931H5	0833-5HO x RZM 931(C)	15.7	0.0	6.4	6.4	4	2.0	1.0	2.1	3.0	5.3	6.7	5.0
1941H5	0833-5HO x RZM 941(C)	20.3	7.9	11.4	17.0	3	4.0	1.0	0.0	3.3	5.3	6.3	5.0
CR111H5	0833-5HO x RZM CR011(C)	22.3	12.4	27.3	27.3	3	2.3	1.7	0.0	4.7	7.0	7.7	6.4
Z125H5	0833-5HO x Z025(C)	19.7	13.1	33.3	33.3	3	3.3	0.3	2.1	4.0	6.0	7.0	5.7
1942H5	0833-5HO x RZM 0942	23.7	7.4	11.3	12.6	3	5.3	0.0	3.1	3.0	4.7	6.0	4.6
01-FC1030H5	0833-5HO x FC1030(C)	22.0	28.6	37.8	45.7	3	3.7	2.0	1.4	5.7	7.0	8.3	7.0
1927-4H5	0833-5HO x RZM 9927-4	21.3	6.7	11.6	14.6	3	3.3	2.3	2.6	5.0	7.3	8.0	6.8
1929-62H5	0833-5HO x RZM 9929-62	24.7	0.0	0.0	0.0	3	3.7	1.0	1.6	3.3	5.3	6.0	4.9
1930-35H5	0833-5HO x RZM 9930-35	21.0	0.0	5.3	8.8	3	0.7	0.3	1.8	4.0	6.7	6.7	5.8
1929-4H5	0833-5HO x RZM 9929-4	23.0	5.5	8.5	11.6	3	0.7	0.0	0.0	3.3	5.3	6.3	5.0
1924-2H5	0833-5HO x RZM 9924-2	20.0	3.5	11.9	11.9	3	5.3	0.3	4.7	3.3	6.7	7.3	5.8

TEST 102. EVALUATION OF EXPERIMENTAL HYBRIDS FOR NONBOLTING, SALINAS, 2001-2002

(cont.)

Variety	Description	Stand Count No.	% Bolting 6/29	% Bolting 8/05	% Bolting 9/04	Emerg Score	Downey Mildew 4/05	Downey Mildew 5/23	Root Rot %	Root Rot 7/25	Powdery Mildew 8/08	Powdery Mildew 8/23	Mean
Hybrids with C790-15CMS x C833-5													
Y190H7	0833-5(Sp)aa x Y090	16.3	0.0	0.0	0.0	4	2.7	0.3	1.6	3.3	6.0	6.7	5.3
Y190H6	0833-5H50 x Y090	22.0	0.0	0.0	2.8	3	2.0	0.7	3.1	4.3	7.0	7.3	6.2
Y175H6	0833-5H50 x RZM Y75 (C)	23.0	2.9	8.8	11.4	3	5.3	1.7	1.4	3.0	6.0	7.3	5.4
1931H6	0833-5H50 x RZM 931 (C)	23.0	7.0	8.4	9.8	3	3.7	1.0	1.4	4.0	6.0	7.0	5.7
1941H6	0833-5H50 x RZM 941 (C)	23.3	2.8	15.2	16.8	3	4.0	2.0	3.2	3.7	5.7	6.7	5.3
CR111H6	0833-5H50 x CR011 (C)	23.3	7.2	22.7	28.6	3	2.3	1.3	4.3	4.0	5.7	6.7	5.4
Z125H6	0833-5H50 x Z025 (C)	23.7	8.6	22.7	28.4	3	1.3	2.0	1.4	3.7	5.7	7.3	5.6
Hybrids with C790-15CMS													
Y190H50	C790-15CMS x Y090	22.0	0.0	3.2	3.2	3	2.3	0.0	0.0	2.7	5.3	6.3	4.8
Y175H50	C790-15CMS x RZM Y75 (C)	23.3	8.5	15.4	19.7	3	3.7	2.3	4.2	3.0	6.0	7.3	5.4
R176-89H50	C790-15CMS x RZM R076-89	18.3	5.6	14.1	14.1	3	3.0	0.7	0.0	2.7	5.3	7.0	5.0
1931H50	C790-15CMS x RZM 931 (C)	20.3	1.3	7.2	9.0	3	4.7	1.3	0.0	2.3	6.0	6.7	5.0
1941H50	C790-15CMS x RZM 941 (C)	23.0	5.7	15.2	20.4	3	4.7	1.3	1.3	2.7	5.3	7.0	5.0
CR111H50	C790-15CMS x RZM CR011 (C)												
Z125H50	C790-15CMS x Z025 (C)	19.3	14.0	29.1	34.6	3	5.0	2.3	1.6	3.3	6.0	7.3	5.6
1942H50	C790-15CMS x RZM 0942	22.3	11.2	33.6	37.8	3	1.3	1.7	1.7	3.7	5.7	7.0	5.4
		21.0	6.4	11.3	12.9	3	2.3	1.7	1.6	2.7	4.7	6.3	4.6
01-FC1030H50	C790-15CMS x FC1030 (C)	23.7	14.4	27.1	32.8	3	3.0	1.0	1.4	4.3	6.0	6.7	5.7
R078H50	C790-15CMS x R978	28.0	4.8	11.9	19.0	2	5.7	3.3	0.0	3.7	5.3	8.0	5.7
R178H50	C790-15CMS x RZM-ER-% R978	27.3	2.2	7.9	13.7	2	5.7	0.3	0.0	4.3	6.7	8.3	6.4
R180H50	C790-15CMS x RZM-ER-% R980	27.7	5.0	11.9	16.7	3	4.0	0.3	0.0	3.7	5.7	7.7	5.7
Y169H50	C790-15CMS x RZM-ER-% Y969	25.3	17.2	32.8	40.5	3	2.0	0.3	2.5	3.7	5.7	7.3	5.6
Y167H50	C790-15CMS x RZM-ER-% Y967	24.3	1.3	9.6	13.7	3	3.0	0.7	1.4	4.0	5.7	7.7	5.8
Y171H50	C790-15CMS x RZM-ER-% Y971	24.3	8.3	13.8	13.8	3	2.0	0.0	0.0	4.7	5.7	8.0	6.1
R170H50	C790-15CMS x RZM-ER-% R970	24.3	1.3	9.4	12.3	3	4.3	0.0	0.0	3.3	6.0	7.3	5.6
R136H50	C790-15CMS x RZM-ER-% R936	25.7	20.6	37.3	42.2	3	2.7	0.3	2.7	4.0	6.7	8.0	6.2

A166

TEST 102. EVALUATION OF EXPERIMENTAL HYBRIDS FOR NONBOLTING, SALINAS, 2001-2002

(cont.)

Variety	Description	Stand Count No.	% Bolting 6/29	% Bolting 8/05	% Bolting 9/04	Emerg Score	Downey Mildew 4/05	Downey Mildew 5/23	Root Rot %	Root Rot 7/25	Powdery Mildew 8/08	Powdery Mildew 8/23	Mean
R140H50	C790-15CMS x RZM-ER-% R940,R954	25.3	7.6	12.7	14.2	3	4.3	2.8	0.0	3.0	5.3	7.0	5.1
R143H50	C790-15CMS x RZM-ER-% R943	26.0	19.4	33.7	36.2	3	5.0	1.3	1.3	3.3	5.3	6.7	5.1
P129H50	C790-15CMS x PMR-RZM P029-#(C)	26.0	7.5	10.1	19.1	3	4.7	3.0	1.1	2.7	5.7	6.3	4.9
P130H50	C790-15CMS x PMR-RZM P030-#(C)	25.3	9.2	32.2	33.6	3	3.3	2.7	0.0	3.0	5.3	6.3	4.9
P118-6H50	C790-15CMS x P918-6	27.0	1.2	7.4	11.1	3	3.3	0.0	0.0	2.7	5.3	6.0	4.7
P125-12H50	C790-15CMS x P925-12	24.7	20.6	38.4	42.3	3	1.7	0.7	0.0	4.7	6.3	6.7	5.9
N124H50	C790-15CMS x NR-RZM N024	24.3	4.1	5.6	7.0	3	4.3	3.0	0.0	4.3	6.0	6.3	5.6
1933H50	C790-15CMSxRZM-ER-% 9933	26.3	7.7	16.6	21.7	3	2.0	1.0	1.3	4.3	6.7	7.3	6.1
1932H50	C790-15CMSxRZM-ER-% 9932	21.0	4.8	23.6	28.4	3	3.7	1.0	0.0	4.3	6.0	7.3	5.9
1924H50	C790-15CMSxRZM-ER-% 9924	22.3	7.1	22.2	25.2	3	2.3	1.7	1.3	3.7	5.7	7.0	5.4
1941H50	C790-15CMSxRZM-ER-% 9941	23.7	8.8	18.6	21.4	3	0.3	0.0	0.0	3.3	6.0	7.0	5.4
Topcross hybrids with popn-931													
1931H50(Iso)	C790-15CMSxRZM-ER-% 9931	26.0	2.5	9.7	11.1	3	0.7	0.0	0.0	3.7	5.3	6.7	5.2
1931H50	C790-15CMSxRZM 931(C)	23.7	11.4	22.9	22.9	3	2.7	1.3	2.9	4.3	6.0	7.0	5.8
1931H2	9831-3HO x RZM 931(C)	19.7	1.3	20.8	20.8	3	3.0	1.7	2.1	4.3	5.0	6.3	5.2
1931H27	9831-4HO x RZM 931(C)	21.7	3.2	10.1	14.9	3	2.7	1.7	1.6	5.3	6.3	6.7	6.1
1931H28	0831-4-7HO x RZM 931(C)	15.0	11.7	13.3	13.3	4	2.0	1.0	3.9	4.7	5.7	6.0	5.4
1931H29	0831-4-10HO x RZM 931(C)	18.0	0.0	5.2	5.2	4	3.3	1.7	4.0	4.7	5.7	6.0	5.4
1931H62	0836-1H5 x RZM 931(C)	20.3	13.4	21.6	26.5	3	2.7	1.3	0.0	4.7	6.0	6.7	5.8
1931H63	0836-7H5 x RZM 931(C)	20.3	4.6	11.6	11.6	3	5.7	1.0	1.9	3.0	4.7	5.7	4.4
1931H64	0834-2H5 x RZM 931(C)	24.3	8.3	22.0	27.6	3	1.7	1.3	1.4	5.0	6.0	6.7	5.9
1931H67	0837-6H5 x RZM 931(C)	20.3	6.6	16.6	19.9	3	4.3	0.7	0.0	4.7	5.7	6.3	5.6

(cont.)

Variety	Description	Stand Count No.	% Bolting 6/29	% Bolting 8/05	9/04	Emerg Score	Downey Mildew 4/05	Downey Mildew 5/23	Root Rot %	Root Rot 7/25	Powdery Mildew 8/08	Powdery Mildew 8/23	Mean
Topcross hybrids with Y90													
Y190H50	C790-15CMS x Y090	22.3	0.0	8.8	11.7	3	2.7	0.7	1.4	4.3	6.0	6.7	5.7
Y190H2	9831-3HO x Y090	20.0	2.0	3.5	5.4	3	1.0	0.7	3.5	3.7	5.3	6.7	5.2
Y190H3	C562HO x Y090	23.0	9.7	22.4	25.5	3	1.3	0.3	1.4	5.0	6.7	7.0	6.2
Y190H5	0833-5HO x Y090	16.3	0.0	3.7	6.3	4	3.3	0.7	8.8	4.3	5.7	6.3	5.4
Y190H6	0833-5H50 x Y090	21.3	0.0	7.7	7.7	3	2.0	1.3	6.1	5.0	6.3	7.3	6.2
Y190H27	9831-4HO x Y090	17.7	2.2	4.7	9.0	4	1.7	0.0	1.2	4.3	6.0	6.3	5.6
Y190H28	0831-4-7HO x Y090	10.3	3.3	6.7	10.0	4	1.3	0.0	0.0	4.3	5.7	5.7	5.2
Y190H29	0831-4-10HO x Y090	14.3	0.0	6.4	9.2	4	0.7	0.0	0.3	3.3	5.0	6.3	4.9
Y190H45	9867-1HO x Y090	21.7	4.9	22.3	22.3	3	0.7	1.0	5.2	4.0	6.0	6.3	5.4
Y190H46	9869-6HO x Y090	20.3	0.0	12.9	14.8	4	2.7	1.0	3.4	5.0	6.0	7.0	6.0
Y190H62	0836-1H5 x Y090	16.3	1.9	3.7	8.0	3	1.7	1.7	2.2	3.3	5.3	5.7	4.8
Y190H63	0836-7H5 x Y090	18.3	0.0	7.0	9.8	3	1.7	0.3	0.0	2.0	5.0	5.3	4.1
Y190H64	0834-2H5 x Y090	20.3	1.6	9.7	11.3	3	2.0	0.0	1.6	4.7	6.3	7.3	6.1
Y190H67	0837-6H5 x Y090	20.7	1.8	4.9	11.1	3	2.7	0.7	1.8	5.0	6.3	7.0	6.1
Y190H80	0808-9H5 x Y090	18.7	3.2	11.6	13.0	4	2.7	0.7	4.8	4.0	5.7	6.0	5.2
Y190H81	0808-15H5 x Y090	16.7	0.0	8.5	8.5	4	3.7	0.3	0.0	4.0	5.3	6.0	5.1
Y190H82	0833-5H2 x Y090	13.0	2.2	7.0	7.0	4	2.0	0.3	5.3	4.3	5.3	6.0	5.2
Y190H83	0833-5H27 x Y090	13.7	2.2	7.0	12.1	4	1.7	1.3	0.0	3.7	5.3	6.0	5.0
Y190H84	0833-5H45 x Y090	15.3	2.6	13.6	18.0	4	1.7	0.7	2.6	5.0	6.3	7.0	6.1
Y190H85	0833-5H46 x Y090	20.3	1.3	7.9	13.3	4	2.0	0.3	0.0	4.3	7.0	7.0	6.1
Y190H35	0835aa x Y090	24.3	3.9	14.1	15.3	3	1.3	0.7	1.2	4.3	6.0	6.3	5.6
Y190H36	0836aa x Y090	23.3	4.6	9.8	12.8	3	0.7	0.0	0.0	5.0	6.3	7.0	6.1
Y190H51	0841HO x Y090	24.7	2.8	13.2	16.3	3	0.3	0.0	0.0	5.0	6.7	7.0	6.2
Y190H55	0835HO x Y090	22.7	8.5	14.9	17.6	3	1.0	1.3	0.0	4.7	6.3	6.7	5.9
Y190H56	0836HO x Y090	21.3	1.9	8.2	9.6	3	3.3	0.7	0.0	4.7	6.3	6.7	5.9

(cont.)

Variety	Description	Stand Count No.	% Bolting 6/29	8/05	9/04	Emerg Score	Downey Mildew 4/05	5/23	Root Rot %	Powdery Mildew 7/25	8/08	8/23	Mean
Topcross hybrids with Y90 (cont.)													
Y191H69	9869aa x Y090	18.7	1.5	12.8	14.6	3	3.0	1.7	0.0	4.7	6.0	6.7	5.8
Y191H70	9869HO x Y090	21.0	11.0	19.1	22.6	3	1.7	1.3	1.4	5.0	7.0	7.7	6.6
Y191H61	0841H5 x Y090	21.7	3.3	6.1	7.7	3	1.3	0.0	0.0	4.7	6.3	6.7	5.9
Y191H65	0835H5 x Y090	20.3	1.5	4.6	9.9	3	1.7	0.3	0.0	4.7	6.0	7.0	5.9
Y191H66	0836H5 x Y090	21.7	3.0	10.7	13.7	3	1.7	1.7	0.0	5.0	7.0	8.3	6.8
Mean		22.1	6.8	15.6	18.8	3.1	2.7	1.0	1.6	4.1	6.1	6.9	5.7
LSD (.05)		4.9	8.8	13.3	14.3	17.8	3.3	1.9	4.6	1.5	1.2	1.4	1.1
C.V. (%)		13.7	80.3	52.6	47.2	0.9	75.6	116.7	182.5	22.4	12.7	12.3	11.6
F value		5.1**	12.0**	8.5**	8.5**	2.4**	1.4*	1.3*	1.4*	2.7**	2.8**	2.1**	3.1**

A169

100 entries x 3 reps., sequential
2001
1-row plots, 17.5 ft. long

Planted: November 7, 2001

Not harvested for yield

Variety	Description	Stand Count No.	% Bolting 6/29	8/05	9/04	Emerg Score	Downey Mildew 4/05	5/23	Root Rot %	7/25	Powdery Mildew 8/08	8/23	Mean
Checks													
US H11	11-3-99	26.3	0.0	2.5	5.0	3	4.7	0.7	0.0	6.0	7.7	8.7	7.4
SS-NB3	Spreckels, 1996	28.7	1.1	3.5	4.6	2	3.7	0.3	0.0	5.7	7.7	8.0	7.1
Beta 4776R	Betaseed, 8-31-01	27.3	4.9	24.3	30.4	3	5.0	0.7	0.0	5.0	6.0	5.7	5.6
HH141	Holly, 8-16-01	25.7	3.9	11.5	14.0	3	3.7	1.7	0.0	5.0	6.3	7.0	6.1
01-US75	Inc. 00-US75	26.7	5.0	10.2	10.2	2	3.0	1.7	3.7	6.0	8.7	9.0	7.9
01-C37	Inc. U86-37, 99-C37	24.7	0.0	1.3	1.3	3	8.0	2.0	2.7	6.0	8.0	9.0	7.7
01-SP22-0	Inc. 00-SP22-0	26.0	72.2	84.7	85.9	3	9.0	1.3	1.3	6.0	7.0	7.3	6.8
97-US22/3	Inc. Y009 (US22/3)	27.3	69.0	78.8	84.1	3	2.0	0.7	1.1	6.0	8.0	8.3	7.4
1930-19	NB 8930-19 (A,aa)	27.7	0.0	0.0	0.0	2	6.0	1.3	0.0	2.3	3.7	4.3	3.4
1929-62	RZM 9929-62aa x A	25.0	0.0	1.4	1.4	3	12.0	3.7	3.9	1.7	3.3	4.3	3.1
Multigerm, open-pollinated lines													
R078(Iso)	Inc. R978 (C78)	24.0	10.9	16.5	16.5	3	9.0	5.0	0.0	3.7	5.3	6.0	5.0
R178	RZM-ER-% R978	25.3	14.9	30.7	30.7	3	13.0	4.7	0.0	4.7	5.7	6.7	5.7
R980	RZM-ER-% R780/2,...	24.3	46.5	72.6	76.6	3	7.7	3.3	0.0	4.7	5.7	7.0	5.8
R180	RZM-ER-% R980	26.7	8.9	21.3	21.3	2	4.7	2.3	0.0	4.3	6.0	7.0	5.8
R039	Inc. R539, (C39R)	22.7	20.9	42.6	45.4	3	4.3	2.3	3.3	3.3	5.3	6.3	5.0
Y090	Inc. FS prog. selection	24.7	1.6	13.8	17.6	3	9.0	2.7	2.9	4.0	6.0	6.7	5.6
Y190	Inc. Y090	16.0	4.4	11.1	14.8	4	5.3	1.7	0.0	3.3	5.3	5.7	4.8
Y191	Inc. FS composite	23.3	6.7	11.5	11.5	3	5.3	1.0	0.0	3.3	5.0	5.7	4.7
Y969(Iso)	RZM-ER-% Y769, (C69)	21.7	11.9	32.8	34.4	3	5.0	4.0	1.4	3.7	5.7	6.0	5.1
Y169	RZM-ER-% Y969	24.3	15.4	38.0	47.8	2	10.0	4.7	1.3	3.7	5.3	6.0	5.0
Y167	RZM-ER-% Y967	22.7	22.0	41.8	46.0	3	4.0	2.7	7.1	4.0	5.7	6.0	5.2
Y171	RZM-ER-% Y971	23.0	15.7	24.5	24.5	3	8.0	0.7	0.0	4.7	6.7	7.3	6.2
Y175	RZM Y75(C)	24.3	10.9	19.0	19.0	3	9.0	3.7	0.0	4.0	6.0	7.0	5.7
R136	RZM-ER-% R936	24.7	29.4	45.0	50.2	3	6.0	2.0	6.4	5.0	8.0	8.0	7.0
R140	RZM-ER-% R940,R954	25.7	19.4	38.1	40.5	3	7.7	2.0	7.1	4.3	6.0	6.3	5.6

TEST 202. EVALUATION OF BREEDING LINES AND POPULATIONS FOR NONBOLTING, SALINAS, CA, 2001-2002

(cont.)

Variety	Description	Stand Count No.	% Bolting 6/29	% Bolting 8/05	% Bolting 9/04	Emerg Score	Downey Mildew 4/05	Downey Mildew 5/23	Root Rot %	Root Rot 7/25	Powdery Mildew 8/08	Powdery Mildew 8/23	Mean
Multigerm, open-pollinated lines (cont.)													
R143	RZM-ER-% R943	23.3	25.7	42.4	44.1	2	14.3	5.0	1.3	3.0	5.3	6.0	4.8
R021	RZM R926,R927,(C26,C27)	26.7	27.6	48.5	52.3	2	11.0	2.7	0.0	4.3	6.0	6.7	5.7
R176-89	RZM R076-89	23.3	8.3	22.0	23.5	3	9.0	1.0	1.6	3.0	4.3	5.3	4.2
R170	RZM-ER-% R970	21.0	0.0	5.0	5.0	3	7.3	2.7	4.2	4.0	5.3	5.7	5.0
R176-89-18	RZM R076-89-18	27.7	11.8	27.8	35.0	2	15.3	0.3	0.0	5.0	6.3	7.0	6.1
P127	PMR-P027-#(C),(WB97)	26.7	9.0	16.9	16.9	3	6.7	2.0	9.5	5.3	7.0	7.7	6.7
P128	PMR P028-#(C),(WB242)	25.3	5.3	13.1	17.1	3	9.3	0.3	4.0	2.7	4.0	4.7	3.8
P129	PMR-RZM P029-#(C)	24.0	5.4	11.3	17.8	3	6.3	3.0	4.3	2.3	4.7	5.7	4.2
P130	PMR-RZM P030-#(C)	23.7	18.0	32.5	37.2	3	9.3	3.0	2.6	3.0	5.0	6.0	4.7
P118-6	Inc. P918-6	24.0	1.4	8.3	8.3	3	4.0	1.3	0.0	3.7	5.0	4.7	4.4
P125-12	Inc. P925-12	22.0	30.2	37.9	37.9	3	9.0	2.0	3.0	4.0	5.7	6.0	5.2
P007/08	PMR-RZM P807-2,R808-7	22.3	8.7	8.7	8.7	3	9.7	2.3	1.7	1.7	3.3	3.0	2.7
Smooth root lines													
01-EL0204	RZM 00-EL0204	24.3	48.2	69.3	75.3	3	8.3	3.7	0.0	5.7	6.7	7.7	6.7
SR96	95H5L,EL SR, 3/01	25.0	50.6	61.1	62.4	3	10.3	2.7	6.7	5.3	6.3	6.7	6.1
SR95	El SM, 3/01	24.0	64.6	84.6	88.8	2	13.0	5.3	0.0	5.0	5.7	7.0	5.9
SR94	EL SM, 3/01	24.0	45.1	59.9	66.0	3	9.3	5.3	3.0	4.7	5.7	7.0	5.8
SR93	EL SM, 3/01	25.7	84.1	85.3	85.3	2	10.7	2.7	1.2	6.0	7.0	7.0	6.7
SR80	EL SM, 3/01	21.3	62.2	80.4	80.4	3	6.3	2.3	3.0	5.0	6.0	6.7	5.9
SR87	EL SM, 3/01	25.0	67.7	74.1	74.1	2	13.7	5.0	1.2	5.0	6.0	7.0	6.0
94H525	EL SM, 3/01	28.7	54.7	60.5	62.7	2	12.0	5.0	1.1	5.3	7.0	7.3	6.6
Multigerm, s[f],Aa populations & lines													
0931	RZM 9931aa x A	25.0	19.9	25.2	29.5	3	8.7	1.7	0.0	4.0	6.0	6.0	5.3
1931	RZM 931(C)aa x A	23.3	11.7	18.8	20.2	3	9.7	2.3	1.4	4.3	5.7	6.7	5.6
1931(Iso)	RZM-ER-% 9931 (A,aa)	26.3	4.2	6.9	8.0	3	9.7	2.7	1.1	4.3	5.3	6.3	5.3
0941	RZM 9941aa x A	20.3	4.6	20.1	20.1	3	5.0	2.0	0.0	4.0	5.7	5.7	5.1
1941	RZM 941(C)aa x A	18.0	20.8	43.8	52.2	3	9.0	2.7	0.0	3.0	5.3	6.3	4.9

TEST 202. EVALUATION OF BREEDING LINES AND POPULATIONS FOR NONBOLTING, SALINAS, CA, 2001-2002

(cont.)

Variety	Description	Stand Count No.	% Bolting 6/29	8/05	9/04	Emerg Score	Downey Mildew 4/05	5/23	Root Rot %	7/25	Powdery Mildew 8/08	8/23	Mean
Multigerm, S^f, Aa populations & lines (cont.)													
1941(Iso)	RZM-ER-% 9941 (A,aa)	24.0	2.6	8.4	9.8	3	7.0	0.7	1.4	4.3	6.0	6.3	5.6
Z025	RZM Z925aa x A	18.3	18.5	32.7	32.7	3	5.3	2.7	0.0	5.0	7.0	7.0	6.3
Z125	RZM Z025(C)aa x A	21.3	16.5	31.9	35.0	3	9.7	1.7	0.0	5.0	6.3	7.0	6.1
CR011	RZM CR910,11,12(C)aa x A	23.3	33.4	54.8	54.8	3	8.0	3.0	0.0	5.0	6.7	7.0	6.2
CR111	CR11(C)aa x A(C)	20.3	35.2	62.9	66.1	3	6.0	2.7	0.0	5.0	6.7	6.7	6.1
1942	RZM 0941aa x A	24.7	6.6	13.3	16.1	3	7.7	3.0	0.0	2.3	4.7	5.0	4.0
01-FC1030	FC1030(C)aa x A	24.7	42.5	58.2	61.1	3	8.3	4.0	0.0	5.0	6.3	7.0	6.1
1933	RZM-ER-% 9933 (A,aa)	26.0	1.1	10.0	10.0	3	4.0	0.3	0.0	4.7	5.7	5.7	5.3
1932	RZM-ER-% 9932 (A,aa)	27.7	19.1	38.8	44.8	3	4.7	1.3	1.3	4.7	6.7	7.3	6.2
1924	RZM-ER-% 9924 (A,aa)	23.0	5.7	27.0	32.6	3	6.7	2.3	0.0	5.0	6.0	5.3	5.4
N124	NR-RZM N024(galls) (A,aa)	21.0	4.2	18.0	19.5	3	8.0	5.3	0.0	3.3	4.7	5.3	4.4
N172	NR-RZM N972 (A,aa)	23.3	31.4	50.4	57.3	3	10.7	3.7	0.0	4.3	6.0	5.3	5.2
N112	NR-RZM P912 (A,aa)	24.0	15.8	31.2	37.0	2	6.7	3.0	2.7	2.3	4.0	4.7	3.7
1930-19	NB 8930-19 (A,aa)	28.0	0.0	1.1	1.1	3	12.0	3.3	1.2	2.0	4.3	4.7	3.7
1930-35A	RZM 9930-35A	20.3	17.9	47.4	50.4	3	1.7	0.7	0.0	3.7	5.3	5.7	4.9
Monogerm, S^f, Aa populations & lines													
N165-9M	Inc. N065-9(A,aa)M	22.7	4.6	8.8	8.8	3	7.7	7.0	2.8	1.3	3.7	3.0	2.7
N165-9HO	NR-RZM N065H5 x N065-9	15.7	3.9	8.4	8.4	4	4.3	5.0	0.0	2.3	4.0	5.0	3.8
N165-9H50	C790-15CMS x N065-9	21.0	0.0	6.2	7.6	3	2.7	2.7	0.0	2.7	5.0	5.7	4.4
N165	NR-RZM N065mm(g) (A,aa)	17.7	0.0	1.5	4.8	4	3.3	1.7	0.0	3.3	5.3	5.3	4.7
N167M	Inc. N067-#(C),N066-1(g) (A,aa)	20.7	1.5	8.1	9.6	3	1.0	2.3	3.3	2.7	5.0	5.7	4.4
1848M	RZM-ER-% 9818,0848,...	21.0	4.9	13.0	14.9	3	2.0	1.3	5.9	3.3	5.7	6.0	5.0
1869	RZM0869-#(C)aa x A,(C869)	21.3	2.6	9.0	9.0	3	1.3	1.0	6.1	4.3	6.0	7.0	5.8
1869HO	9869HO x RZM 0869-#(C),(C869CMS)	23.7	2.8	11.4	18.5	3	2.3	1.0	4.2	4.7	6.3	7.3	6.1
1842	842(C)mmaa x A	26.0	1.3	9.4	15.4	3	2.3	1.3	7.6	4.3	5.7	7.0	5.7
1842HO(A)	0841HOmm x 842(C)	24.3	1.5	3.9	9.2	3	0.7	0.0	1.5	5.0	6.3	7.0	6.1

TEST 202. EVALUATION OF BREEDING LINES AND POPULATIONS FOR NONBOLTING, SALINAS, CA, 2001-2002

(cont.)

Variety	Description	Stand Count No.	% Bolting 6/29	% Bolting 8/05	% Bolting 9/04	Emerg Score	Downey Mildew 4/05	Downey Mildew 5/23	Root Rot %	7/25	Powdery Mildew 8/08	Powdery Mildew 8/23	Mean
Monogerm,S^f,Aa populations & lines (cont.)													
1835	835(C)mmaa x A	25.0	5.3	21.7	23.1	2	0.7	0.0	10.5	4.3	5.0	6.3	5.2
1835HO	0835HOmm x 835(C)	22.0	9.0	16.4	16.4	3	1.0	0.3	4.5	3.7	5.3	6.3	5.1
1836	836(C)mmaa x A	21.7	3.0	10.3	13.3	3	2.3	0.3	1.3	4.3	6.3	6.7	5.8
01-FC123	FC123(C)mmaa x A	21.0	1.6	9.5	11.1	3	2.0	0.0	6.3	4.7	5.7	6.3	5.6
01-FC123H5	0833-5HO x FC123(C)	27.7	0.0	3.4	4.6	2	3.3	0.7	4.7	4.0	6.3	7.3	5.9
01-FC1014	00-FC1014mmaa x A	24.3	24.8	42.6	45.3	3	2.7	0.0	3.1	4.7	7.3	7.0	6.3
01-FC1014H5	0833-5HO x FC1014	22.7	21.1	32.3	35.2	2	4.0	0.7	1.5	4.7	6.0	6.7	5.8
0833-5A(Sp)	RZM 9833-5(T-O)mmA	24.7	0.0	5.4	5.4	3	5.3	2.0	8.1	2.7	4.0	5.3	4.0
0833-5HO(Sp)	RZM 9833-5(T-O)HO x 9833-5	28.0	6.0	14.3	19.0	2	3.7	2.7	0.0	2.7	5.0	6.0	4.6
0833-5H50	C790-15CMS x 9833-5	26.3	1.6	8.5	10.1	2	1.7	0.0	2.8	3.7	5.0	6.0	4.9
1833-5(Iso)	RZM 0833-5(Sp)(A,aa)	28.0	0.0	3.4	6.9	2	6.3	1.7	2.6	2.7	4.3	5.7	4.2
1833-5	Inc. 0833-5(Sp)(A,aa)	28.3	2.5	3.5	5.9	2	2.0	1.3	3.7	2.3	4.0	5.7	4.0
1833-5-8	Inc. 8833-5-8(A,aa)	23.3	1.3	1.3	1.3	3	1.3	1.7	18.4	2.0	3.0	4.7	3.2
1833-5-11	Inc. 8833-5-11(A,aa)	25.3	0.0	0.0	0.0	3	0.7	0.3	10.8	1.0	2.3	2.3	1.9
1835-11	Inc. 8835-11(A,aa)	24.0	3.7	7.7	7.7	2	3.0	0.7	6.0	0.7	3.0	2.3	2.0
1835-11H5	0833-5HO(Iso) x 8835-11	24.7	0.0	2.7	3.9	3	2.0	1.0	9.0	3.0	4.0	5.3	4.1
1835-26	Inc. 8835-26(A,aa)	23.7	5.5	24.1	24.1	3	2.3	0.3	8.2	4.3	6.0	6.0	5.4
1835-26H5	0833-5HO(Iso) x 8835-26	25.7	13.3	27.3	32.8	2	2.0	0.3	2.6	4.7	6.7	7.0	6.1
OT-33	mm,OT,NB from Biancardi, 3/01	19.7	8.3	33.9	35.5	4	4.0	1.3	1.8	3.0	5.0	5.0	4.3
00-790-15	Inc. F92-790-15, (C790-15)	25.3	0.0	3.8	3.8	3	2.0	1.7	2.8	1.7	4.3	5.0	3.7
F_1 population hybrids													
Y190	Inc. Y090	15.7	6.7	20.0	23.9	4	4.7	2.0	0.0	4.0	6.0	6.7	5.6
Y190H11	CR011aa x Y090	22.7	10.6	34.2	38.3	3	10.0	1.3	2.7	4.7	6.0	6.7	5.8
Y190H41	0941aa x Y090	20.0	8.3	20.0	23.3	3	4.0	1.3	0.0	3.7	5.0	6.3	5.0
Y190H25	Z025aa x Y090	21.3	14.9	33.1	33.1	3	5.0	2.0	0.0	4.3	6.0	6.3	5.6
Y190H31	0931aa x Y090	26.0	16.7	24.3	33.4	3	8.3	2.3	0.0	4.3	6.0	7.0	5.8

TEST 202. EVALUATION OF BREEDING LINES AND POPULATIONS FOR NONBOLTING, SALINAS, CA, 2001-2002

(cont.)

Variety Description	Stand Count No.	% Bolting 6/28	8/05	9/04	Emerg Score	Downey Mildew 4/05	5/23	Root Rot %	7/25	Powdery Mildew 8/08	8/23	Mean
Mean	23.8	15.2	26.1	28.6	2.8	6.2	2.1	2.4	4.0	5.6	6.2	5.3
LSD (.05)	4.3	13.7	14.9	14.2	0.8	6.2	2.6	5.8	1.2	1.2	1.2	1.0
C.V. (%)	11.1	56.0	35.5	30.9	17.0	62.6	77.2	148.9	19.5	13.8	11.6	11.4
F value	3.4**	14.7**	17.7**	20.9**	2.8**	2.5**	2.5**	2.3**	7.4**	6.8**	8.5**	11.1**

40 entries x 3 reps., sequential
1-row plots, 17.5 ft. long

Planted: November 7, 2001
Not harvested for yield

Variety	Description	Stand Count No.	% Bolting 6/28	8/05	9/04	Emerg Score	Downey Mildew 4/05	5/23	Root Rot %	Powdery Mildew 8/08	8/23	Mean
Checks												
01-SP22-O	Inc. 00-SP22-0	26.3	74.0	85.5	87.6	3	3.7	2.3	1.3	7.3	7.3	7.3
0930-19	8930-19aa x A	28.0	2.3	3.6	3.6	2	6.0	1.7	0.0	4.3	5.0	4.7
Inc. S₁ progeny lines												
1930-35A	RZM 9930-35A	24.7	26.0	56.3	56.3	3	2.7	1.0	1.5	5.3	5.7	5.5
1929-62	RZM 9929-62aa x A	25.0	1.3	1.3	1.3	3	7.0	3.0	2.5	4.0	4.0	4.0
1927-4	RZM 9927-4aa x A	24.7	15.5	29.5	37.2	3	4.7	1.3	2.5	8.3	8.0	8.2
1929-4	RZM 9929-4aa x A	26.0	6.6	16.8	18.1	3	2.0	0.3	0.0	3.7	5.0	4.3
1924-2	RZM 9924-2aa x A	23.0	7.2	17.3	18.9	2	9.0	5.3	17.6	4.7	5.7	5.2
1930-19	NB 8930-19 (A,aa)	26.3	0.0	0.0	0.0	2	7.0	2.3	0.0	3.7	3.7	3.7
Z025-9	Z025-9aa x A	25.7	5.2	12.8	21.8	3	1.7	3.0	1.4	4.7	5.3	5.0
0929-112	8929-112aa x A	24.0	29.7	41.4	48.5	3	9.0	2.7	0.0	6.3	6.3	6.3
Z131-20	Inc. Z931-20 (A,aa)	24.7	16.4	43.4	47.4	3	4.7	4.3	0.0	4.7	5.0	4.8
CR009-1	CR009-1aa x A	21.7	39.5	63.6	65.0	3	8.7	2.0	4.7	6.0	7.0	6.5
CR110-14-2	Inc. CR910-14-2 (A,aa)	18.7	2.1	0.0	0.0	4	3.0	0.3	5.8	3.7	4.0	3.8
CR110-5	Inc. CR910-5 (A,aa)	21.7	37.6	51.4	54.6	3	8.3	3.3	7.7	4.7	5.7	5.2
CR112-5	Inc. CR812-5 (A,aa)	25.7	17.3	31.0	31.0	2	9.7	4.7	8.9	7.0	7.0	7.0
Z131-14	Inc. Z931-14 (A,aa)	24.7	2.7	4.1	6.7	2	10.0	3.0	0.0	4.3	5.0	4.7
Z131-18	Inc. Z931-18 (A,aa)	23.0	0.0	2.9	2.9	3	1.7	1.3	1.5	3.7	4.0	3.8
1935-6	Inc. 9935-6 (A,aa)	26.0	2.3	3.7	4.8	3	17.7	7.3	0.0	1.3	2.3	1.8
1936-14	Inc. 9936-14 (A,aa)	25.0	0.0	0.0	0.0	3	13.3	1.0	0.0	5.3	6.0	5.7
1931-56	Inc. 9931-56 (A,aa)	27.0	0.0	3.7	3.7	3	8.3	3.3	2.5	3.3	2.7	3.0
1931-201	Inc. 9931-201 (A,aa)	25.3	0.0	0.0	0.0	3	12.7	2.0	1.5	3.3	4.0	3.7

A175

TEST 302. EVALUATION OF SELECTED PROGENY LINES FOR NONBOLTING, SALINAS, CA, 2001-2002

(cont.)

Variety	Description	Stand Count No.	% Bolting 6/28	8/05	9/04	Emerg Score	Downey Mildew 4/05	5/23	Root Rot %	Powdery Mildew 8/08	8/23	Mean
Increase FS progeny lines												
R178-5	Inc. R978-5	26.3	0.0	2.7	4.2	3	9.7	2.0	1.2	5.3	5.3	5.3
R178-6	Inc. R978-6	27.0	0.0	1.1	1.1	2	4.0	2.0	0.0	5.3	5.7	5.5
R178-11	Inc. R978-11	25.7	1.2	5.1	5.1	2	9.3	0.3	0.0	5.0	5.3	5.2
R180-11	Inc. R980-11	20.3	0.0	0.0	0.0	3	3.7	2.7	0.0	5.7	7.3	6.5
R180-16	Inc. R980-16	27.3	0.0	0.0	0.0	3	4.3	3.0	2.5	7.7	7.7	7.7
R180-21	Inc. R980-21	24.0	0.0	1.3	1.3	3	2.0	2.0	0.0	6.3	6.7	6.5
Y168-8	Inc. Y968-8	23.7	0.0	4.3	4.3	3	5.0	2.0	0.0	6.0	5.7	5.8
Y168-13	Inc. Y968-13	22.7	7.4	18.3	23.9	3	2.3	0.0	1.3	4.0	5.0	4.5
Y168-16	Inc. Y968-16	23.3	4.3	15.7	21.4	3	2.7	1.0	1.3	4.3	5.3	4.8
Y167-5	Inc. Y967-5	26.0	1.4	5.2	5.2	2	4.0	2.7	0.0	4.7	5.0	4.8
Y172-1	Inc. Y972-1	28.0	1.2	16.7	17.9	2	14.7	9.7	2.4	5.3	5.7	5.5
Y172-5	Inc. Y972-5	26.0	1.3	4.0	4.0	3	5.7	2.3	6.1	5.3	6.3	5.8
Y172-7	Inc. Y972-7	20.7	0.0	1.4	1.4	3	6.3	2.0	7.1	5.3	6.0	5.7
Y175-13	Inc. Y975-13	25.7	14.1	34.9	37.4	3	8.7	4.0	0.0	4.7	5.7	5.2
R181-22	Inc. R981-22	23.0	0.0	0.0	0.0	3	4.3	2.0	0.0	4.7	5.3	5.0
R176-89-5	RZM R076-89-5	20.7	3.3	16.2	21.2	3	1.7	1.0	0.0	3.3	4.7	4.0
R176-89-5-4	Inc. R976-89-5-4	27.3	0.0	2.5	3.6	3	0.3	0.3	0.0	3.3	4.0	3.7
R176-89-5NB-4	Inc. R976-89-5NB-4	27.7	4.7	10.8	15.6	2	2.0	0.3	0.0	3.7	4.7	4.2
R176-89-5-13	Inc. R976-89-5-13	24.0	5.6	21.8	26.6	3	1.3	0.3	2.5	5.3	6.0	5.7
Mean		24.7	8.3	15.8	17.6	2.8	6.1	2.4	2.1	4.9	5.4	5.1
LSD (.05)		4.1	8.4	11.8	12.6	0.8	7.1	3.0	4.9	1.4	1.4	1.1
C.V. (%)		10.1	62.6	46.2	44.1	17.4	72.0	78.5	144.1	17.2	15.6	13.7
F value		2.5**	24.7**	24.0**	23.2**	2.2**	2.6**	3.2**	4.0**	7.8**	6.6**	9.9**

A176

TEST 402. EVALUATION OF HYBRIDS WITH SELECTED PROGENY LINES FOR NONBOLTING, SALINAS, CA, 2001-2002

Planted: November 7, 2001
Not harvested for yield

40 entries x 3 reps., sequential
1-row plots, 17.5 ft. long

Variety	Description	Stand Count No.	% Bolting 6/28	8/05	9/04	Emerg Score	Downey Mildew 4/05	5/23	Root Rot %	Powdery Mildew 8/08	8/23	Mean
Checks												
Monohikari	Seedex, L7383, 3-1-00	28.7	72.9	88.8	90.9	2	3.0	2.0	2.5	6.7	6.3	6.5
0930-19H50	C790-15CMS x 8930-19	27.0	2.4	9.7	12.1	3	3.0	0.7	1.2	5.3	6.0	5.7
Restests and line increases												
1930-35H50	C790-15CMS x RZM 9930-35	20.7	0.0	11.4	17.6	3	1.7	0.3	0.0	4.7	5.7	5.2
1929-62H50	C790-15CMS x RZM 9929-62	23.0	0.0	2.5	8.3	3	3.3	0.3	0.0	5.3	6.0	5.7
1927-4H50	C790-15CMS x RZM 9927-4	26.0	10.4	24.8	33.9	3	2.0	0.3	2.6	6.7	7.7	7.2
1929-4H50	C790-15CMS x RZM 9929-4	20.3	6.5	15.4	18.3	3	0.7	1.0	1.6	5.3	5.7	5.5
1924-2H50	C790-15CMS x RZM 9924-2	23.7	4.2	11.2	11.2	3	3.0	1.7	0.0	5.3	5.7	5.5
1930-19H50	C790-15CMS x NB 8930-19	25.7	0.0	2.6	2.6	2	2.3	0.7	0.0	5.3	6.0	5.7
Z025-9H50	C790-15CMS x Z825-9	26.0	5.1	19.4	23.1	2	0.0	0.7	1.4	5.7	6.0	5.8
0929-112H50	C790-15CMS x 8929-112	27.7	7.3	16.9	19.4	2	6.0	1.3	0.0	6.0	7.3	6.7
0929-114H50	C790-15CMS x 8929-114	27.0	6.0	20.8	20.8	2	2.3	0.7	2.5	5.0	5.7	5.3
CR009-1H50	C790-15CMS x CR909-1	26.0	24.5	43.7	50.1	2	4.0	0.7	1.3	7.3	7.7	7.5
Hybrids with S1 progeny lines												
CR110-14-2H50	C790-15CMS x CR910-14-2	26.3	3.5	4.7	4.7	2	1.3	0.7	3.9	5.7	6.3	6.0
CR110-5H50	C790-15CMS x CR910-5	26.3	44.3	65.8	72.0	9	9.7	1.7	1.3	7.0	7.3	7.2
CR112-5H50	C790-15CMS x CR812-5	25.0	17.8	56.5	60.6	2	4.7	2.3	2.5	7.0	8.3	7.7
Z131-14H50	C790-15CMS x Z931-14	24.0	0.0	4.1	4.1	2	6.3	1.7	0.0	5.7	6.3	6.0
Z131-18H50	C790-15CMS x Z931-18	23.3	0.0	6.9	8.3	3	4.0	0.7	1.3	5.3	5.7	5.5
1935-6H50	C790-15CMS x 9935-6	25.0	1.4	8.0	8.0	3	10.3	1.3	0.0	5.3	6.0	5.7
1936-14H50	C790-15CMS x 9936-14	25.0	0.0	1.3	4.0	3	2.7	0.7	0.0	5.7	6.0	5.8
1931-56H50	C790-15CMS x 9931-56	26.3	0.0	7.4	9.9	2	3.3	0.0	0.0	5.0	5.3	5.2
1931-201H50	C790-15CMS x 9931-201	29.3	1.1	3.4	3.4	2	5.0	1.0	0.0	5.3	6.0	5.7

A177

(cont.)

Variety	Description	Stand Count No.	% Bolting 6/28	8/05	9/04	Emerg Score	Downey Mildew 4/05	5/23	Root Rot %	Powdery Mildew 8/08	8/23	Mean
Hybrids with FS progeny lines												
R178-5H50	C790-15CMS x R978-5	26.0	0.0	2.5	2.5	2	5.3	1.0	1.2	5.7	6.3	6.0
R178-6H50	C790-15CMS x R978-6	25.7	0.0	2.8	4.1	3	2.7	0.3	0.0	6.7	7.3	7.0
R178-11H50	C790-15CMS x R978-11	28.3	1.1	7.0	8.1	1	2.0	0.0	0.0	5.7	5.7	5.7
R180-11H50	C790-15CMS x R980-11	27.0	0.0	3.5	3.5	2	0.3	0.3	0.0	5.3	6.0	5.7
R180-16H50	C790-15CMS x R980-16	25.0	1.4	5.5	5.5	2	1.7	0.3	0.0	6.0	7.3	6.7
R180-21H50	C790-15CMS x R980-21	27.0	1.1	1.1	1.1	3	1.0	0.7	0.0	5.7	6.7	6.2
Y168-8H50	C790-15CMS x Y968-8	24.7	0.0	0.0	1.3	3	2.3	1.3	2.8	5.0	5.3	5.2
Y168-13H50	C790-15CMS x Y968-13	25.3	5.3	18.6	22.6	3	1.7	0.3	1.4	5.3	5.7	5.5
Y168-16H50	C790-15CMS x Y968-16	27.7	4.6	10.8	17.9	13	4.7	1.3	0.0	5.3	6.3	5.8
Y167-5H50	C790-15CMS x Y967-5	24.3	4.2	5.5	5.5	3	1.7	0.7	0.0	4.7	5.7	5.2
Y172-1H50	C790-15CMS x Y972-1	26.3	0.0	9.9	16.3	2	5.3	1.7	1.2	6.0	7.0	6.5
Y172-5H50	C790-15CMS x Y972-5	26.0	3.9	10.7	14.5	2	3.0	0.3	0.0	5.7	6.3	6.0
Y172-7H50	C790-15CMS x Y972-7	27.0	0.0	0.0	0.0	2	2.3	1.0	9.9	5.3	6.0	5.7
Y175-13H50	C790-15CMS x Y975-13	27.3	3.7	17.2	20.9	3	6.3	3.3	0.0	4.7	6.0	5.3
R181-22H50	C790-15CMS x R981-22	25.3	0.0	1.3	2.7	3	2.3	0.7	0.0	5.0	5.3	5.2
R176-89-5H50	C790-15CMSxRZM R076-89-5	26.7	3.6	13.3	16.0	2	0.7	0.3	0.0	5.0	5.7	5.3
R176-89-5-4H50	C790-15CMSxR976-89-5-4	27.0	0.0	1.2	6.2	3	0.0	0.0	0.0	5.3	6.3	5.8
R176-89-5NB-4H50	C790-15CMSxR976-89-5NB-4	26.0	0.0	5.1	9.0	3	1.0	0.0	0.0	4.0	5.3	4.7
R176-89-5-13H50	C790-15CMSxR976-89-5-13	25.0	0.0	0.0	0.0	2	1.3	0.0	1.4	6.0	6.7	6.3
Mean		25.8	5.9	13.5	16.0	2.9	3.1	0.9	1.0	5.6	6.3	5.9
LSD (.05)		3.5	8.0	10.0	10.7	5.2	4.7	1.9	3.1	1.2	0.9	0.8
C.V. (%)		8.4	82.9	45.3	41.2	112.3	94.0	134.6	188.2	13.3	8.7	8.5
F value		2.2**	23.2**	28.3**	27.3**	1.1NS	1.9*	1.2NS	2.7**	2.6**	5.5**	5.6**

A178

48 entries x 4 reps., sequential
1-row plots, 11 ft. long

Planted: April 22, 2002
Harvested: October 28, 2002

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	End Use Code	Stand Count No.	Harv. Count No.	Beets/100' No.	Root Rot %	Bolting %	Bolting Code	RJAP %	PM 10/5	Rhizomania Resistance DI	Rhizomania Resistance %R(0-4)	Visual Foliar
Checks																
US H11	susc. ck., 11/3/99	6448	20.78	15.48	5	18	15	159	8.0	0.0	2	85.4	7.5	4.5	43.8	3
R039	Inc. R539, (C39R)	11724	33.41	17.58	5	17	15	152	9.5	0.0	2	84.5	4.5	2.9	98.3	1
01-C37	susc. ck., Inc. U86-C37	8229	24.21	17.00	5	17	15	150	13.2	0.0	2	87.0	8.3	3.5	75.7	3
R136	RZM-ER-% R936,(C79-8)	10750	31.13	17.27	5	19	18	170	2.9	0.0	2	83.6	8.5	3.0	97.2	1
Y167	RZM-ER-% Y967 (C67/2)	12201	33.36	18.38	5	17	16	152	7.1	1.8	3	84.7	4.3	3.0	96.5	1
Y175	RZM Y075	12155	35.22	17.23	5	17	16	152	1.7	0.0	2	84.0	5.8	3.0	92.5	1
01-SP22-0	susc.ck.,Inc.00-SP22-0	5809	17.82	16.30	5	18	13	164	25.0	0.0	2	85.4	4.8	4.1	46.4	3
R021	RZM R926,R927,(C26,C27)	10386	30.98	16.83	5	17	14	155	18.6	0.0	2	83.8	7.5	3.0	98.6	1
Beta 4776R	2/5/02	12254	36.71	16.63	5	17	15	157	14.7	0.0	2	86.1	5.0	3.0	100.0	1
Beta 6600	susc. ck., 2/5/02	11361	30.25	18.77	5	18	13	161	15.9	0.0	2	88.3	6.8	2.8	50.3	3
Angelina	3/19/02	12990	34.27	18.92	5	18	16	159	6.9	0.0	2	86.8	9.0	2.9	100.0	1
Monohikari	susc. ck., 4/5/02	8226	24.40	16.85	5	18	15	161	10.9	0.0	2	87.2	7.0	3.8	66.4	3
HM-E17	susc. ck., 3/21/02	8422	23.71	17.70	5	17	13	152	15.6	0.0	2	87.0	5.8	3.8	67.6	3
Dorotea	2/21/02	12096	34.46	17.55	5	16	16	145	9.6	0.0	2	87.9	6.0	3.4	90.3	1
Monodoro	3/21/02	11298	32.79	17.23	5	18	14	159	19.8	0.0	2	86.4	5.0	3.5	83.7	3
Beta 4001R	9/25/01	16168	44.98	17.95	5	16	15	145	4.4	0.0	2	87.8	4.0	2.6	96.7	1
Plant Introductions																
Beta vulgaris																
PI 504181	SD Wild leaf beet	0	0.00	0.00	6	9	3	82	27.7	61.0	1	0.0	1.3	3.3	91.7	3
PI 518168	SD IDBBNR 9600	5666	15.84	17.98	5	17	14	150	16.5	0.0	2	85.3	5.3	4.2	46.6	3
PI 518644	SD IDBBNR 9604	4624	15.24	15.23	5	14	11	130	18.3	0.0	2	85.8	3.3	4.4	40.7	3
PI 518645	SD IDBBNR 9605	6584	22.31	14.77	5	11	10	100	4.2	0.0	2	85.3	4.5	4.4	39.1	3
PI 546504	SD TURKESTANSKAJA	473	2.35	10.13	6	11	9	100	18.3	65.5	1	62.7	5.3	3.4	84.7	1
PI 611060	SD Swiss chard	5323	20.79	12.80	6	15	5	136	57.7	81.6	1	79.0	4.8	3.8	65.0	3
PI 614824	SD Jaltuskovskaja 116	4969	16.75	14.77	5	16	14	141	6.4	0.0	2	85.3	5.5	4.1	54.5	3
PI 614828	SD AT3994-4	5211	14.32	18.17	5	16	14	141	2.8	0.0	2	83.5	4.5	3.7	70.0	3
Beta macrocarpa																
PI 540557	SD WB 820	520	2.20	11.80	6	11	9	95	38.2	88.2	1	65.6	4.5	3.1	96.9	3
Beta vulgaris subsp maritima																
PI 504269	SD Wild beet	383	2.51	7.60	6	16	11	148	28.3	74.6	1	65.7	5.5	4.0	56.1	3
PI 504277	SD Wild beet	1910	5.30	18.00	6	13	12	120	22.1	88.4	1	81.8	4.8	3.0	95.9	3
PI 504279	SD Wild beet	298	2.28	6.68	6	14	10	123	27.9	95.9	1	67.3	3.3	3.4	82.5	3

A179

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	End Use Code	Stand Count No.	Harv. Count No.	Beets/100' No.	Root Rot %	Bolting %	Bolting Code	RJAP %	PM 10/5	Rhizomania Resistance DI	Rhizomania Resistance %R(0-4)	Visual Foliar
Beta vulgaris subsp maritima (cont.)																
PI 518331	SD IDBBNR 5825	1980	7.54	13.07	6	13	12	114	11.3	86.8	1	66.3	3.3	2.8	100.0	1
PI 518404	SD IDBBNR 5898	4189	14.04	12.30	6	11	10	100	17.7	32.3	1	67.5	3.5	3.1	92.5	1
PI 540570	SD WB 824	529	2.38	11.13	6	13	8	118	15.4	73.0	1	56.3	4.5	3.2	92.5	3
PI 540609	SD WB 863	1336	5.68	12.23	6	14	13	130	12.5	65.8	1	61.9	5.8	3.0	97.9	1
PI 540613	SD WB 867	1853	7.04	12.98	6	15	14	139	1.8	75.9	1	64.9	4.3	3.0	100.0	1
PI 540615	SD WB 869	1767	6.60	13.07	6	15	13	132	13.9	71.3	1	72.3	3.0	3.0	98.4	1
PI 540645	SD WB 899	2062	8.06	12.68	6	15	15	136	3.1	63.5	1	59.3	3.0	3.2	93.0	1
PI 540647	SD WB 901	1840	6.58	13.80	6	15	14	136	1.9	78.9	1	61.1	4.3	2.7	97.9	1
PI 540641	SD WB 905	1641	5.87	14.20	6	15	12	134	8.3	81.7	1	68.5	5.5	3.0	100.0	1
PI 540652	SD WB 906	1581	5.80	13.57	6	12	9	105	18.4	40.0	1	58.9	4.3	2.9	100.0	1
PI 540656	SD WB 910	1618	6.81	11.88	6	16	16	143	3.1	77.9	1	57.5	6.8	3.1	90.3	1
PI 540661	SD WB 915	4712	14.00	15.48	6	16	15	141	0.0	62.6	1	75.3	5.3	2.9	98.3	1
PI 540665	SD WB 919	1880	7.43	12.52	6	15	13	136	1.7	28.8	1	61.6	5.5	3.3	91.3	1
Beta vulgaris subsp. vulgaris																
PI 535828	SD ALMAMONO	10320	36.84	14.10	5	9	9	80	6.3	0.0	2	86.4	6.3	4.2	48.0	3
PI 535830	SD POLY PAST	5351	17.31	14.95	5	7	6	61	14.3	0.0	2	83.3	5.0	5.1	25.5	3
PI 535831	SD TYTAN POLY	4463	34.89	6.80	4	12	7	109	7.7	0.0	2	74.9	6.3	4.6	41.8	3
PI 590695	SD IDBBNR 4360	6611	20.79	15.70	7	15	14	134	0.0	0.0	2	82.4	6.0	3.5	65.6	3
PI 614825	SD AT3984A	5923	16.95	17.42	5	15	12	134	8.7	0.0	2	85.1	4.0	3.9	62.1	3
Checks																
01-US75	susc.ck., Inc. 00-US75	8364	26.20	15.95	5	16	15	148	4.2	0.0	2	84.8	8.0	3.4	81.2	3
Y190	RZM Y090	12806	35.27	18.15	5	13	12	118	2.1	0.0	2	83.8	5.5	2.9	100.0	1
Mean		5985.5	18.64	14.53		14.7	12.4	133.5	12.6	29.1		75.7	5.2	3.4	79.3	
LSD (.05)		2274.5	6.86	1.83		2.5	4.4	22.5	19.4	12.0		7.8	1.5	0.7	24.1	
C.V. (%)		27.2	26.34	9.00		12.1	25.2	12.1	109.9	29.5		7.4	20.9	14.9	21.7	
F value		29.7**	25.71**	32.79**		9.2**	4.0**	9.2**	2.5**	72.9**		30.1**	8.2**	5.3**	6.6**	

A180

TEST 6902. EVALUATION OF PLANT INTRODUCTIONS (PI's), SALINAS, CA, 2002

(cont.)

| Variety | Description | Acre Yield | | Sucrose | End Use | Stand Count | Harv. Count | Beets/ 100' | Root Rot | Bolting | | RJAP | PM | Rhizomania Resistance | | Visual |
| | | Sugar Lbs | Beets Tons | % | Code | No. | No. | No. | % | % | Code | % | 10/5 | DI | %R(0-4) | Foliar |

Bolting: % bolting based upon counts where % bolting = 100(number bolter/stand count); code = 1 (B_, 100% annual); 2 = bb, 0% biennial; 3 = mixed.

End use: 1=chard; 2=DDR-like; 3=DDR,chard,spinach; 4=fodder; 5=sugar; 6=wild beet type; 7=mixed.

Powdery mildew: scored on a scale of 0 to 9, where 9 = highly susceptible.

Rhizomania: DI (disease index) based upon scoring individual roots on scale of 0 to 9, where 0 = no visual symptoms, 5 = moderate rhizomania, 7 = severe, 9 = dead due to rhizomania. %R (0-4) (%resistant) based upon assigning ratings of 0-4 as resistant and 5-9 as susceptible. Visual foliar based upon apparent rhizomania reaction by color of foliage where yellowish = susceptible and greenish = resistant; 1 = resistant; 2 = segregating; 3 = susceptible (yellowish).

Note: Rhizomania caused significant effects in this test but tap and main roots did not develop intense bearding. Most bearding occurred on smaller lateral roots where scoring is difficult. Thus, high level of apparent escapes occurred.

Root Rot: Primarily due to Sclerotium rolfsii. Rotted roots were counted and weighed at harvest but not included in sugar sample.

RJAP: Raw juice apparent purity where RJAP = 100(%S/%soluble solids).

A181

EVALUATION OF PAIRCROSSES (FULL SIBS) OF Y90, SALINAS, CA, 2002

	Test 3602 (VY)				Test 502 (NB)		
	Sugar			Powdery	%	Downey	Powdery
Variety	Yield	Sucrose	RJAP	Mildew	Bolting	Mildew	Mildew
	Lbs	%	%	Score	9/04	4/05	Mean
Checks							
R176-89-5	17519	16.80	84.1	2.7	28.8	1.7	3.7
Y190	15888	16.60	83.7	3.0	32.4	5.0	4.9
Y090	18858	17.93	84.6	4.0	17.4	4.0	5.3
Y191-# = RZM Y969(PX)							
Y190 - 1	18539	17.67	82.9	4.3	0.0	5.0	5.1
- 2	19468	17.57	86.0	2.7	55.9	5.0	4.3
- 3	19542	17.57	84.9	5.3	9.6	4.0	6.1
- 4	20581	17.90	84.8	5.3	31.9	0.7	6.1
- 5	16250	17.00	81.6	6.0	52.4	2.3	7.3
- 6	16997	18.00	82.8	4.3	2.4	7.0	6.1
- 7	16773	17.70	82.4	4.0	25.6	3.3	5.6
- 8	18782	17.40	84.9	4.3	15.3	5.7	5.0
- 9	18681	16.60	82.6	6.3	8.8	3.0	5.4
-10	17917	17.57	85.7	4.0	6.5	1.7	4.2
-11	16719	16.40	84.0	3.3	25.1	10.7	4.9
-12	18684	16.63	85.2	3.0	0.0	4.3	4.9
-13	19632	17.73	88.5	5.7	2.0	2.7	6.8
-14	16497	17.43	84.2	5.0	10.2	0.3	5.6
-15	18626	17.00	84.9	5.3	2.8	0.7	5.7
-16	18151	16.77	85.8	4.3	43.2	2.3	5.2
-17	16333	17.57	85.2	5.7	4.8	3.0	6.4
-18	18538	17.10	83.8	4.0	0.0	4.3	3.9
-19	20977	17.23	84.0	5.3	0.0	1.7	5.3
-20	19224	17.30	84.0	5.0	25.8	3.0	6.3
-21	16107	17.53	84.6	4.3	23.3	1.0	5.6
-22	16619	17.47	84.8	3.0	10.7	3.7	4.7
-23	16654	16.80	83.9	5.0	0.0	3.7	5.9
-24	16870	17.83	85.5	5.3	4.4	2.7	6.2
-25	17239	17.67	86.7	4.0	0.0	4.7	6.9
-26	16580	17.47	83.0	1.7	3.3	4.3	4.4
-27	17239	16.10	82.6	3.0	23.3	3.7	5.9
-28	18022	17.27	84.9	6.0	0.0	2.3	7.4
-29	16767	17.80	84.7	3.7	2.8	6.7	4.3
-30	18145	17.30	83.6	4.0	3.3	6.7	6.6
-31	15946	16.03	82.7	4.7	51.4	5.7	5.9
-32	14648	16.00	83.7	3.3	8.3	6.7	3.3

Variety	Test 3602 (VY)				Test 502 (NB)		
	Sugar Yield Lbs	Sucrose %	RJAP %	Powdery Mildew Score	% Bolting 9/04	Downey Mildew 4/05	Powdery Mildew Mean
Y191-# = RZM Y969(PX)							
Y190 -33	17035	16.33	85.7	4.3	25.8	2.0	5.0
-34	19006	18.13	88.2	3.3	18.5	6.0	5.2
-35	16728	18.07	84.8	2.7	40.2	2.0	5.1
-36	17060	17.63	86.2	6.0	31.0	2.3	6.9
-37	18359	17.67	85.7	3.7	3.0	1.0	6.0
-38	18358	16.90	82.8	6.0	14.4	4.0	7.4
-39	19008	17.00	86.0	4.3	26.9	5.3	5.4
-40	19310	18.03	83.8	4.3	0.0	1.3	5.2
-41	15529	17.30	81.6	3.7	0.0	1.7	5.7
-42	16080	18.13	82.9	2.3	10.2	2.0	5.0
-43	17850	18.07	86.5	0.7	0.0	2.3	2.6
-44	15010	16.23	84.3	0.7	2.1	5.7	4.1
-63	17180	18.17	83.7	4.3	11.2	2.0	6.2
-64	18193	17.00	85.9	5.0	2.0	1.7	6.4
-65	19009	17.97	87.8	4.0	21.8	1.0	6.0
-66	19845	17.67	83.2	4.3	45.1	2.3	5.7
-67	17104	17.10	82.2	3.3	16.6	3.7	4.3
-68	18142	17.93	83.0	4.0	0.0	3.0	5.4
-69	16554	17.90	82.0	2.3	2.2	1.7	4.7
-70	15803	16.80	81.5	4.3	0.0	7.0	6.1
-71	15409	17.00	81.3	4.0	11.1	2.3	5.1
-72	17858	17.93	85.4	6.0	12.6	1.0	6.3
-73	18137	17.87	83.6	6.0	15.0	1.0	7.0
-74	17736	17.03	86.0	2.7	22.3	2.3	5.2
-75	18453	17.50	83.6	5.3	0.0	0.7	5.3
-76	17409	17.30	87.4	4.3	4.3	4.0	5.2
-77	16879	17.87	82.6	4.7	22.5	1.0	6.3
-78	16842	17.40	83.6	3.3	56.1	0.7	5.7
-79	16037	17.53	86.5	4.3	0.0	3.0	6.6
-80	17744	17.20	85.8	1.7	0.0	2.3	4.2
-81	18378	17.00	84.4	5.0	0.0	1.7	5.6
-82	15740	16.33	80.7	4.3	6.1	1.3	5.4
-83	18354	18.40	84.7	2.7	12.6	0.7	4.8
-84	19222	16.90	85.4	4.7	2.0	2.0	4.3
-85	19217	17.43	83.2	4.7	2.8	3.7	5.4
-86	18520	16.83	85.6	4.3	13.6	2.0	5.4

	Test 3602 (VY)				Test 502 (NB)		
Variety	Sugar Yield	Sucrose	RJAP	Powdery Mildew	% Bolting	Downey Mildew	Powdery Mildew
	Lbs	%	%	Score	9/04	4/05	Mean
Y190 - 87	17297	16.67	86.1	5.7	12.9	5.0	5.0
- 88	17784	16.77	83.2	6.0	0.0	3.7	4.7
- 89	16543	14.83	82.2	3.3	24.5	7.7	4.4
- 90	19805	16.77	85.7	5.0	0.0	2.0	5.0
- 91	19564	16.43	84.8	4.3	4.4	4.3	5.1
- 92	15279	17.00	83.4	3.0	9.9	3.7	4.1
- 93	19178	17.27	83.8	3.0	14.3	1.7	5.1
- 94	18349	16.43	85.6	3.0	2.8	4.0	4.3
- 95	17661	17.37	84.9	0.7	2.1	7.3	3.4
- 96	19553	16.77	84.8	3.0	0.0	5.3	4.0
- 97	17620	17.17	83.4	4.7	64.8	3.3	6.8
- 98	21033	17.87	86.5	2.0	0.0	2.7	3.4
- 99	19375	16.73	84.8	0.7	56.5	2.0	2.3
-100	16658	17.60	84.6	4.0	74.8	1.0	4.6
-101	17561	17.47	85.2	3.3	33.7	2.0	5.0
-102	17326	16.53	84.1	2.7	16.2	2.3	5.1
-103	14051	16.97	85.0	4.3	37.8	2.7	5.8
-104	20290	17.90	84.8	3.7	14.1	0.3	4.8
-105	19746	17.17	84.7	3.7	6.7	1.7	5.3
-106	19130	16.63	82.8	3.7	34.4	4.0	4.3
-107	15732	17.33	81.9	3.7	3.0	2.3	4.2
-108	18494	17.83	83.5	4.7	16.9	6.3	5.2
-109	18770	17.07	84.9	2.7	33.2	4.3	4.8
-110	18082	17.07	83.0	4.7	12.3	5.0	6.2
Mean	17749.7	17.26	84.3	4.0	16.2	3.3	5.3
LSD (.05)	3269.7	1.15	3.6	1.8	14.5	3.8	1.0
C.V. (%)	11.4	4.15	2.7	27.6	55.5	71.6	11.7
F value	1.5*	2.22**	1.4*	4.3**	13.4**	2.2**	7.7**

2002 EVALUATION OF PROGENIES FROM Y75, POPN-921, POPN-934

Variety	Test 6602 (RZM) Sugar Yield lbs/a	Sucrose %	RJAP %	PM Score	Tests B702/B1102 (IV) Sugar Yield lbs/a	Sucrose %	Appear Score	Tests 3702/4202 (Yield) Sugar Yield lbs/a	Sucrose %	RJAP %	PM 9/23	Tests 602/1002 (NB) % Bolt 9/4	DM 4/3	Root Rot %	PM Mean
Check Y175	12128	16.93	83.5	5.3	9545	15.90	1.5	18292	16.87	85.1	4.3	32.0	3.7	5.1	4.9
FS's from Y75 (see 602 & 3702)															
Y175 - 1	11574	17.57	83.7	5.3	6128	17.53	3.0	20256	17.33	85.8	5.0	27.9	5.3	0.0	5.8
- 2	14460	17.00	85.0	4.8	11728	16.09	1.0	20152	16.10	84.0	2.7	34.4	7.3	5.0	5.4
- 3	12597	17.60	87.1	5.3	7111	17.79	2.5	19249	15.60	81.1	2.7	11.4	5.7	4.0	4.6
- 4	12264	17.40	84.4	6.8	10100	17.53	2.5	20118	17.10	85.2	5.7	42.5	6.7	5.2	6.2
- 5	10772	16.27	82.8	5.8	8352	17.33	1.0	15247	16.20	82.5	4.7	16.2	8.0	5.3	4.7
- 6	10500	15.80	88.2	5.7	8078	16.72	2.0	16838	16.93	84.8	5.7	0.0	3.3	2.5	5.7
- 7	14761	17.43	86.4	5.0	12880	16.86	2.5	19752	15.80	84.9	3.0	28.3	4.7	4.5	4.4
- 8	13345	17.33	85.6	5.7	12561	17.60	1.5	17752	16.13	85.1	4.3	35.8	5.0	3.2	5.1
- 9	16192	17.50	85.2	5.8	11254	16.51	2.0	20524	16.60	84.5	4.0	7.2	6.3	3.5	4.8
-10	13070	17.23	87.6	5.2	9897	17.34	3.0	15897	15.77	84.0	3.7	6.7	5.3	3.5	4.9
-11	13083	16.57	83.5	5.8	7145	16.14	2.0	18078	16.30	82.3	5.3	0.0	7.7	6.2	5.2
-12	10206	16.60	85.2	5.2	8524	18.76	3.0	14699	14.83	81.6	3.3	0.0	8.3	6.3	4.9
-13	14190	17.07	87.1	4.7	10651	17.59	1.5	19688	16.50	84.4	3.3	34.5	5.7	3.7	4.9
-14	12073	17.20	84.3	4.2	6475	17.52	4.0	16533	16.20	82.4	2.7	66.9	5.3	3.7	4.8
-15	12803	16.80	85.8	5.3	7931	16.82	4.0	17711	15.97	81.5	4.0	47.1	8.3	6.3	6.0
-16	12386	15.40	86.7	6.0	10179	17.70	2.5	19311	15.60	81.1	5.3	30.0	6.3	4.2	6.7
-17	10865	17.13	83.6	5.3	7558	16.98	2.5	16032	16.87	82.7	3.0	15.3	4.0	3.0	5.4
-18	9225	16.03	84.2	5.8	7652	16.98	3.5	15655	16.37	82.8	3.3	2.4	9.7	7.0	6.1
-19	12983	16.43	85.0	7.2	7912	17.64	3.0	16755	15.47	83.7	5.0	31.1	5.3	3.8	5.2
-20	13497	17.30	84.5	4.2	10215	17.27	1.5	17160	16.90	85.3	2.3	44.4	6.3	4.7	4.8
-21	12003	17.17	86.6	3.2	9908	18.20	3.5	18045	16.00	84.5	2.7	2.4	6.0	4.7	3.8

2002 EVALUATION OF PROGENIES FROM Y75, POPN-921, POPN-934

(cont.)

Variety	Test 6602 (RZM) Sugar Yield lbs/a	Sucrose %	RJAP %	PM Score	Tests B702/B1102 (IV) Sugar Yield lbs/a	Sucrose %	Appear Score	Tests 3702/4202 (Yield) Sugar Yield lbs/a	Sucrose %	RJAP %	PM 9/23	Tests 602/1002 (NB) % Bolt 9/4	DM 4/3	Root Rot %	PM Mean
FS's from Y75 (see 602 & 3702) (cont.)															
Y175 -22	13178	16.13	85.8	5.7	11420	16.48	2.0	20117	15.77	84.5	4.7	7.1	5.0	4.0	5.3
-23	14090	16.93	85.6	5.8	8277	17.97	3.0	21127	16.23	85.3	4.0	22.8	5.3	4.5	5.8
-24	10721	15.70	85.1	5.0	6507	15.27	3.5	19578	16.27	84.1	4.7	46.6	2.3	2.2	5.6
-25	13747	16.90	84.9	6.2			2.0	19085	16.60	86.0	4.0	27.8	1.7	1.5	5.8
-26	14234	16.50	83.9	6.0			2.0	17649	15.87	83.6	5.0	26.9	5.0	4.0	6.3
-27							3.0	17559	15.77	81.7	5.3	50.4	2.0	2.5	6.8
-28							2.5	17962	15.90	83.1	4.0	0.0	1.7	1.8	5.4
-29							1.5	19917	15.67	84.4	3.3	37.9	1.7	1.5	4.4
-30							2.5	17463	16.17	84.1	5.0	40.1	3.0	3.0	5.3
-31							2.0	20796	16.90	84.5	3.7	34.7	1.7	2.0	3.8
Y175 -32							2.0	14346	15.23	81.8	4.3	30.2	2.3	0.0	5.0
S₁'s from 921 (see tests 1002 & 4202)															
1921 -1					10490	15.93	3.0								
-2					4103	18.20	3.5								
-3					6178	16.08	3.0								
-4					8794	16.68	4.5								
-5					9009	15.03	3.0								
-6					5050	16.61	5.0								
-7					2517	15.20	5.0								
-8					7243	16.41	3.5								
-9					6254	16.92	3.0								
-10					3572	17.85	3.5								

A186

2002 EVALUATION OF PROGENIES FROM Y75, POPN-921, POPN-934

(cont.)

Variety	Test 6602 (RZM) Sugar Yield lbs/a	Sucrose %	RJAP %	PM Score	Tests B702/B1102 (IV) Sugar Yield lbs/a	Sucrose %	Appear Score	Tests 3702/4202 (Yield) Sugar Yield lbs/a	Sucrose %	RJAP %	PM 9/23	Tests 602/1002 (NB) Bolt % 9/4	DM 4/3	Root Rot %	PM Mean
S₁'s from 921 (see tests 1002 & 4202) (cont.)															
1921 -101	13764	16.27	85.6	5.8				18129	16.27	87.5	4.3	67.3	5.3	0.0	5.4
-102	7969	16.67	84.1	5.7				14788	17.17	82.9	5.0	5.6	9.3	0.0	4.9
-103	8560	16.37	86.5	3.8				18769	17.07	83.7	4.7	73.7	2.7	2.8	4.6
-104								16158	16.97	85.4	3.3	36.5	2.3	0.0	5.2
-105								16872	15.50	84.4	3.7	59.6	7.0	0.0	3.4
-106								15797	16.13	83.0	3.3	86.5	2.0	0.0	5.4
-107								15188	16.17	79.2	5.7	20.6	2.7	0.0	2.3
-108								20386	17.47	86.4	3.3	52.4	2.7	0.0	2.4
-109								15245	15.97	83.9	3.3	84.1	1.7	0.0	3.6
-110								15100	16.67	81.2	4.3	81.7	2.7	0.0	7.4
-111							5.0	15585	15.60	81.3	3.3	100.0	2.7	0.0	6.1
-112							3.5	15583	16.40	82.3	5.7	49.0	4.0	0.0	7.0
-113							4.0	14135	15.23	82.6	3.0	0.0	6.7	0.0	2.4
-114							4.5	13242	14.97	84.9	2.0	44.6	3.7	0.0	3.8
-115							4.0	11859	15.83	80.9	2.0	88.1	2.7	0.0	4.4
1921 -116							4.0					49.1	3.3	0.0	5.0
S₁'s from 934 (see tests 1002 & 4202)															
1934 -101	11762	15.97	84.6	6.3	4798	15.77	2.0	15630	15.37	79.9	4.3	39.9	4.7	0.0	4.9
-102	10750	16.30	87.2	6.8	7061	15.98	3.5	15371	16.80	87.5	6.7	5.6	5.3	0.0	7.6
-103	15037	16.57	85.0	5.5	8557	15.99	2.0	16265	16.57	83.5	4.7	39.7	3.0	0.0	4.4
-104	13305	16.67	81.7	5.5	5450	16.50	3.5	16684	16.27	80.3	4.3	28.8	3.3	0.0	5.3
-105	11971	17.60	85.5	5.0	4333	16.99	4.0	17639	18.00	83.6	3.0	45.7	1.0	0.0	4.3
-106	10394	15.20	85.1	7.0	6866	15.39	3.0	16597	17.43	81.2	6.3	20.4	0.3	0.0	6.7
-107	9232	15.87	81.4	5.5	6666	15.83	4.5	14716	16.07	83.3	3.3	3.0	3.0	0.0	4.9

2002 EVALUATION OF PROGENIES FROM Y75, POPN-921, POPN-934

(cont.)

Column groups: **Test 6602 (RZM)** | **Tests B702/B1102 (IV)** | **Tests 3702/4202 (Yield)** | **Tests 602/1002 (NB)**

Variety	Sugar Yield lbs/a	Sucrose %	RJAP %	PM Score	Sugar Yield lbs/a	Sucrose %	Appear Score	Sugar Yield lbs/a	Sucrose %	RJAP %	PM 9/23	Bolt % 9/4	DM 4/3	Root Rot %	PM Mean
S_1's from 934	(see tests 1002 & 4202)				(cont.)										
1934 -108					10065	17.01	3.0	17739	15.70	85.1	3.7	73.7	3.3	0.0	5.6
-109					3427	15.38	2.5	14004	14.50	84.1	5.7	0.0	0.7	0.0	5.7
-110					10949	15.46	2.5	19496	16.37	85.6	3.0	10.4	2.7	0.0	3.6
-111								15812	15.83	83.8	3.0	20.2	7.3	0.0	5.1
-112								9260	16.07	80.6	4.7	0.0	5.3	0.0	4.8
-113								17285	16.80	79.5	2.0	15.8	2.7	0.0	4.1
F_1 crosses x C36 (C79-8)															
1235 - 1	14479	16.13	84.7	5.8			3.0								
1236 - 1	9865	15.30	86.1	6.5			4.0								
1236 - 2	10065	15.00	86.5	6.7			4.5								
1236 - 3	11064	15.57	84.9	6.8			3.0								
1237 - 1	10148	15.83	87.5	7.0			4.5								
1237 - 2	10522	15.43	84.5	6.3			4.0								

EVALUATION OF HALF-SIB PROGENIES OF CR11, SALINAS, 2002

Variety	Test 3802 (Yield)				Test 702 (NB)			Test 6202 (CLS)			
	Sugar Yield lbs/a	Sucrose %	RJAP %	PM Score	Bolt % 9/4	DM 4/3	PM Mean	Sugar Yield lbs/a	Sucrose %	RJAP %	CLS Score Mean
Checks											
CR110-14-2	13008	16.50	82.9	4.0				9929	15.77	85.1	1.5
CR110-5	12382	15.90	81.6	2.3	48.3	5.7	4.9	9130	15.40	81.6	2.8
CR112-5	15054	15.37	84.5	5.7				9150	11.33	78.1	4.0
CR009-1	14608	16.60	79.4	3.3				13174	16.17	80.1	4.5
Half-sibs of CR111											
CR111 - 1	19865	17.37	83.6	5.7	47.3	6.0	6.2	15300	14.50	80.8	3.2
- 2	19179	16.13	83.2	4.7	56.4	6.3	6.3	14610	14.63	83.8	2.7
- 3	18922	15.73	83.5	4.0	59.1	6.3	5.4	13563	14.87	81.7	3.2
- 4	19381	16.53	84.7	3.3	46.1	6.7	3.7	12367	14.43	81.7	2.5
- 5	17988	16.43	81.0	5.3	78.8	5.3	5.9	15221	15.87	83.1	3.0
- 6	18474	17.03	84.5	3.3	74.7	3.0	5.4	14876	16.13	82.2	1.5
- 7	17964	16.37	83.1	4.7	64.6	3.3	5.6	16729	16.07	85.7	3.8
- 8	17870	15.93	82.1	4.7	65.2	6.7	5.8	13957	14.77	80.3	3.3
- 9	17888	16.10	85.2	5.0	83.7	5.7	5.3	11451	13.63	81.9	3.2
-10	20754	15.63	82.9	3.0	71.3	6.3	5.0	15331	14.53	81.6	2.5
-11	17517	16.80	80.7	5.0	41.1	6.3	6.0	11612	15.27	81.5	3.3
-12	17470	16.13	83.0	5.7	47.3	9.0	6.2	12426	13.93	80.8	2.8
-13	16047	15.60	79.2	6.0	88.1	4.7	6.6	14637	13.73	79.9	4.5
-14	17344	15.87	82.1	5.0	56.7	6.3	5.8	10092	12.43	75.9	4.0
-15	18975	16.20	81.3	4.7	76.3	6.3	6.4	20390	16.10	84.0	3.5
-16	16748	16.00	84.5	5.3	37.0	4.0	5.9	11257	13.57	79.9	3.8
-17	19237	16.30	84.7	3.7	70.1	3.0	5.4	15423	15.23	85.4	3.3
-18	19338	16.67	84.5	4.7	61.5	2.3	6.9	14570	15.00	82.4	3.7
-19	14854	15.23	82.4	4.3	14.8	6.0	5.2	12251	15.03	82.3	1.3
-20	17242	16.40	85.4	4.7	66.1	6.3	6.0	13104	14.50	80.2	4.2

EVALUATION OF HALF-SIB PROGENIES OF CR11, SALINAS, 2002

(cont.)

	Test 3802 (Yield)				Test 702 (NB)			Test 6202 (CLS)			
Variety	Sugar Yield lbs/a	Sucrose %	RJAP %	PM Score	% Bolt 9/4	DM 4/3	PM Mean	Sugar Yield lbs/a	Sucrose %	RJAP %	CLS Score Mean
Half-sibs of CR111 (cont.)											
CR111 -21	20235	16.70	84.3	5.3	60.5	5.3	6.3	9921	12.13	80.8	4.2
-22	17294	16.07	80.8	4.0	58.4	5.7	5.1	11255	13.63	80.4	3.3
-23	17077	16.27	80.4	4.7	57.4	4.7	5.9	12557	15.83	83.3	3.0
-24	19073	16.93	83.1	3.0	71.8	6.3	5.7	10936	15.00	80.1	4.2
-25	19763	17.13	83.7	4.3	80.9	6.7	6.3	12143	13.97	80.3	2.7
-26	19068	17.50	84.4	4.3	76.4	1.0	6.0	13431	15.40	79.6	3.3
-27	17346	15.77	83.1	4.7	52.4	4.0	6.0	9415	13.07	77.0	3.2
-28	17791	17.00	81.1	5.0	62.4	1.3	6.1	14771	16.27	82.5	2.7
-29	18098	16.37	80.9	3.0	73.4	1.3	5.1	12695	13.80	80.0	2.2
-30	19374	17.07	85.9	3.7	85.6	1.7	5.3	12990	14.47	82.5	3.7
-31	16458	15.33	82.3	5.3	80.8	5.0	5.9	10925	11.33	81.4	3.3
-32	17174	16.93	84.0	3.3	66.8	3.0	5.3	15923	15.63	84.1	3.2
-33	18838	16.37	82.9	3.3	49.2	2.3	5.2	12789	14.50	83.8	2.7
-34	18303	16.03	83.2	4.3	87.4	3.7	6.0	12872	13.53	80.3	2.2
-35	17124	16.87	85.3	4.0	28.4	2.3	6.0	13849	15.03	83.6	2.7
-36	19179	16.23	82.5	3.7	62.3	2.0	5.9	13958	15.03	79.7	3.3
-37	19932	16.60	83.4	4.3	36.5	4.0	6.2	15683	15.33	82.1	2.5
-38	19478	15.90	82.5	5.3	55.2	5.0	5.9	9613	12.23	76.9	4.2
-39	17252	16.20	83.0	4.3	45.8	0.0	6.4	11491	13.00	76.8	4.3
-40	19610	16.33	83.2	4.0	17.4	6.0	4.8	13804	14.70	80.0	2.5
-41	18400	16.83	84.5	4.7	15.5	1.7	5.4	14708	16.30	84.3	2.3
-42	19489	15.70	83.1	6.0	65.1	2.7	6.2	13781	13.63	81.4	4.5
-43	19537	16.47	83.4	4.0	69.4	3.7	5.7	9836	12.53	74.5	4.7
-44	18327	16.07	84.0	5.0	72.8	1.7	5.6	15030	15.27	81.6	3.2

EVALUATION OF HALF-SIB PROGENIES OF CR111, SALINAS, 2002

(cont.)

| Variety | Test 3802 (Yield) | | | | Test 702 (NB) | | | Test 6202 (CLS) | | | CLS |
	Sugar Yield lbs/a	Sucrose %	RJAP %	PM Score	% Bolt 9/4	DM 4/3	PM Mean	Sugar Yield lbs/a	Sucrose %	RJAP %	Score Mean
Half-sibs of CR111 (cont.)											
CR111 -45	20067	16.60	85.9	4.3	52.6	3.7	5.7	13897	13.00	79.3	3.0
-46	17772	16.70	84.2	4.0	60.0	4.7	5.6	14693	15.03	81.6	2.5
CR111 -47	16872	16.37	83.2	3.3				10517	13.97	78.9	3.2
-48	17571	16.20	84.5	5.3				13023	14.30	81.9	3.0
-49	17501	16.70	85.0	5.3				14221	15.60	83.4	3.3
-50	18000	16.10	86.7	4.7				13412	13.83	82.3	3.2
-51	18630	16.70	87.8	5.7				15274	13.87	80.9	3.5
-52	18260	16.70	84.0	4.7				16616	15.93	84.3	3.3
-53	16230	16.50	83.4	5.0				13816	14.90	82.8	3.5
-54	18838	16.93	85.5	4.3				13372	14.63	81.4	3.0
-55	17615	15.73	82.1	5.0				14768	15.13	83.2	3.0
-56	18093	17.20	83.1	5.3				15620	15.57	81.6	3.3
-57	17095	15.97	81.1	5.3				8853	12.03	76.7	4.7
-58	17345	17.03	84.5	4.7				15058	15.30	82.8	2.3
-59	18055	16.73	84.1	5.0				14432	14.40	80.6	2.8
-60	17225	16.77	85.6	5.7				12735	15.20	83.1	4.2
-61	14906	14.47	82.0	5.0				9490	12.03	79.1	3.7
-62	17478	16.77	84.0	3.3				11867	13.97	80.9	4.3
-63	15956	16.30	82.1	2.3				11971	14.23	80.3	2.7
-64	18670	16.57	82.6	4.7				8487	12.00	75.1	4.8
-65	16618	16.80	82.3	3.7				13466	15.80	81.7	3.2
-66	18186	16.27	82.3	3.3				13558	14.13	80.4	3.0
-67	19432	17.40	85.7	5.3				11906	13.73	84.7	3.5
-68	17932	17.40	84.8	4.3				11584	13.93	77.3	3.5

EVALUATION OF HALF-SIB PROGENIES OF CR11, SALINAS, 2002
(cont.)

| | Test 3802 (Yield) | | | | Test 702 (NB) | | | Test 6202 (CLS) | | | |
| | Sugar Yield | Sucrose | RJAP | PM | Bolt | DM | PM | Sugar Yield | Sucrose | RJAP | CLS Score |
Variety	lbs/a	%	%	Score	% 9/4	4/3	Mean	lbs/a	%	%	Mean
Half-sibs of CR111 (cont.)											
CR111 -69	18426	16.97	86.1	5.7				13250	14.03	80.7	3.8
-70	18083	17.10	85.1	4.7				12685	15.50	83.5	3.7
-71	14839	15.63	80.9	4.0				12911	15.87	82.4	1.7
-72	17943	16.37	84.7	5.7				12985	14.37	82.0	3.7
-73	19604	17.27	83.4	5.0				15078	16.57	86.6	2.8
-74	18090	17.13	85.6	4.0				12642	15.13	80.8	3.8
-75	13290	15.73	80.7	3.0				14930	15.30	80.9	3.3
-76	18487	16.20	82.8	5.3				14819	15.40	84.3	3.7
-77	13937	16.17	79.6	3.7				15029	16.03	83.0	3.2
-78	19638	17.33	83.2	5.7				13150	14.67	82.1	3.3
-79	16883	16.73	82.5	5.0				15121	15.37	84.6	2.7
-80	14380	16.17	82.9	5.0				13530	14.30	82.8	3.0
-81	18702	16.13	84.2	5.3				17615	15.13	83.6	2.8
-82	15731	17.00	83.0	5.7				13081	15.93	83.0	2.3
-83	19945	16.57	82.2	5.3				12616	13.87	78.4	3.3
-84	17411	16.53	85.0	5.3				16953	15.37	86.1	3.5
-85	18526	16.47	84.3	4.7				14942	14.70	80.9	2.8
-86	19226	17.07	87.2	4.3				13918	14.10	81.8	3.5
-87	18109	15.70	86.7	6.3				12666	13.17	79.7	3.5
-88	21445	17.00	85.4	4.0				16390	15.43	83.9	3.2
-89	18008	17.17	83.3	4.7				15129	15.33	82.3	2.2
-90	18652	16.63	83.3	5.0				14463	14.83	85.7	3.8
Mean	17773.0	16.45	83.4	4.5				13283.0	14.59	81.5	3.2
LSD (.05)	3618.7	1.21	3.9	1.5				3666.6	1.97	5.7	1.1
C.V. (%)	12.6	4.56	2.9	20.1				17.1	8.38	4.3	21.4
F value	1.8**	1.63**	1.5*	2.8**				2.6**	2.87**	1.4*	3.1**

EVALUATION OF HALF-SIB PROGENIES OF FC1030, SALINAS, CA, 2002

Variety	Test 4302 (Yield)					Test 1602 (NB)			Test 5902 (CLS)			
	Sugar Yield lbs/a	Sucrose %	RJAP %	PM Score	Bolt %	Bolt % 9/4	DM 4/3	PM Mean	Sugar Yield lbs/a	Sucrose %	RJAP %	CLS Score Mean
01-FC1030 - 1	17341	17.33	84.3	5.0	4.2	71.3	61.0	5.6	13719	16.57	85.6	2.0
- 2	16873	16.07	82.0	5.0	0.0	46.2	37.9	5.7	14126	16.20	83.6	2.0
- 3	17710	17.47	82.0	4.0	2.6	50.2	47.4	4.8	16172	16.73	81.1	2.7
- 4	17718	16.93	83.8	6.3	2.0	30.7	30.3	5.8	13412	14.53	81.5	3.3
- 5	15119	16.93	84.1	6.3	0.0	70.2	45.1	6.1	13201	16.90	83.0	3.0
- 6	15021	15.07	82.3	5.7	3.9	57.6	46.5	5.4	12311	14.90	81.8	2.0
- 7	16870	17.53	84.6	5.7	0.0	42.1	21.1	6.3	15251	17.03	84.1	2.3
- 8	15773	18.00	84.2	6.0	0.0	52.8	33.3	5.6	11242	16.73	81.0	2.3
- 9	17369	17.37	82.2	6.0	0.0	54.8	53.9	6.3	15182	17.03	83.9	2.0
-10	17906	17.40	83.6	6.3	0.0	44.4	66.1	6.3	12510	16.83	83.7	2.3
-11	17570	17.47	85.0	6.0	0.0	30.7	33.3	6.8	12648	15.97	80.2	2.3
-12	17041	16.97	81.6	5.7	3.9	42.0	26.8	6.4	16691	17.93	84.9	2.7
-13	18077	17.43	83.7	6.0	0.0	50.6	44.1	5.4	14109	17.03	81.9	2.7
-14	14018	16.67	84.0	6.0	0.0	35.7	35.7	5.7	13156	15.87	83.1	2.0
-15	17817	18.73	84.6	5.0	4.2	70.6	35.6	5.6	12198	16.13	80.8	2.0
-16	18784	17.37	87.0	5.0	2.1	67.3	30.1	6.3	17729	17.87	85.2	2.3
-17	16268	17.63	87.0	5.3	0.0	86.7	28.2	6.0	13643	16.27	81.7	2.3
-18	19421	17.53	83.1	5.3	0.0	94.7	14.2	5.7	17008	17.27	84.7	2.0
-19	15570	16.73	83.9	5.7	0.0	92.1	42.1	6.0	15748	16.80	84.0	2.7
-20	15780	17.47	84.0	3.7	0.0	59.3	18.5	5.0	14869	17.23	82.6	1.7
-21	17406	16.93	83.1	4.7	0.0	27.8	23.0	5.0	14587	16.77	82.3	2.3
-22	15774	17.57	83.5	6.0	0.0	66.9	17.2	6.3	10644	17.10	84.0	2.3
-23	14025	16.67	85.3	6.3	0.0	12.7	14.3	5.3	11355	15.17	80.1	2.3
-24	16891	16.17	82.9	5.0	3.9	56.4	7.4	5.7	14452	15.83	80.3	2.0

EVALUATION OF HALF-SIB PROGENIES OF FC1030, SALINAS, CA, 2002

(cont.)

Variety	Test 4302 (Yield)					Test 1602 (NB)			Test 5902 (CLS)			
	Sugar Yield lbs/a	Sucrose %	RJAP %	PM Score	Bolt %	% Bolt 9/4	DM 4/3	PM Mean	Sugar Yield lbs/a	Sucrose %	RJAP %	CLS Score Mean
01-FC1030 -25	15521	17.70	86.0	6.0	0.0	83.2	24.4	6.3	11952	16.83	82.5	2.7
-26	16608	17.37	85.6	6.0	0.0	97.0	14.8	5.9	12291	15.97	82.6	2.3
-27	17602	16.80	84.3	4.7	0.0	75.4	7.2	6.0	16729	16.70	82.6	2.0
-28	16728	17.17	85.7	5.7	0.0	76.1	18.4	6.4	15061	16.63	83.9	1.7
-29	17755	17.50	84.1	5.3	0.0	48.1	16.7	5.9	14689	16.13	82.9	2.7
-30	20376	17.63	84.6	5.7	0.0	64.4	4.2	6.3	14253	17.00	85.9	2.0
-31	15361	16.87	84.7	5.0	9.8	57.9	19.4	5.4	13710	16.20	82.9	2.0
-32	17889	17.50	80.4	5.3	0.0	53.9	23.7	5.1	15020	17.60	84.2	2.3
Mean	16874.5	17.19	84.0	5.5	1.1	58.4	29.4	5.8	14052.1	16.56	82.9	2.3
LSD (.05)	3397.3	1.40	4.0	1.2	4.6	20.5	38.1	1.0	3083.0	1.61	4.4	0.8
C.V. (%)	12.3	5.00	2.9	12.8	247.2	21.4	79.3	10.6	13.4	5.95	3.2	21.4
F value	2.2NS	1.67*	1.1NS	2.7**	1.8*	7.9**	1.3NS	1.9*	2.6**	1.84*	1.0NS	1.7*

EVALUATION OF HALF-SIB PROGENIES FROM POPN-FC123, SALINAS, CA, 2002

Variety	Test 4402 (Yield)				Test 1202 (NB)				Test 5802 (CLS)			
	Sugar Yield lbs/a	Sucrose %	RJAP %	PM Score	Bolt 9/4 %	DM 4/3	PM Mean	Root Rot %	Sugar Yield lbs/a	Sucrose %	RJAP %	CLS Score Mean
01-FC123- 1	17221	16.10	84.3	6.0	36.4	4.2	5.3	0.0	13814	17.47	84.7	2.3
- 2	14795	16.57	87.1	4.7	10.0	4.8	4.1	0.0	10693	16.53	80.9	3.3
- 3	14347	16.17	85.4	5.0	7.5	8.3	3.7	0.0	15176	16.43	82.5	3.3
- 4	13706	16.10	84.2	5.0	9.5	0.0	3.4	0.0	11464	16.50	82.4	4.0
- 5	16166	16.80	82.6	4.7	9.1	8.6	3.7	0.0	11486	16.27	81.3	2.3
- 6	14897	16.70	84.7	5.7	5.6	0.0	3.3	3.7	11060	15.57	82.1	2.7
- 7	16459	16.70	82.7	4.3	21.1	0.0	3.2	0.0	14912	17.80	83.6	2.0
- 8	15239	16.57	85.3	5.3	6.7	8.9	3.3	0.0	12344	16.27	83.4	2.3
- 9	11862	15.70	85.5	5.0	16.9	5.6	3.1	5.6	13903	17.53	85.4	2.7
-10	16604	16.37	82.1	6.3	27.8	6.9	4.0	0.0	10726	17.37	81.8	2.3
-11	13361	16.47	84.2	4.7	5.6	0.0	3.3	4.2	10987	16.13	83.0	2.3
-12	13579	15.83	83.8	4.7	0.0	5.6	3.9	0.0	9396	15.17	81.7	2.3
-13	17749	16.07	88.8	6.0	52.4	0.0	5.3	3.7	14679	17.17	85.3	2.7
-14	16545	16.93	83.4	5.0	0.0	6.7	2.9	0.0	8168	15.97	82.4	1.7
-15	15038	16.93	85.0	4.3	9.5	21.4	2.8	4.2	10213	16.97	84.7	3.0
-16	16404	15.87	84.0	5.0	17.4	2.1	4.2	0.0	12684	15.97	82.2	2.7
-17	17053	16.97	85.9	6.0	10.3	9.5	5.8	0.0	14143	15.83	85.0	2.7
-18	15430	16.50	86.6	4.7	15.1	0.0	3.3	0.0	10513	16.50	84.6	2.7
-19	15910	15.97	87.2	6.0	13.9	0.0	5.1	0.0	11855	16.07	85.2	4.0
-20	16399	16.83	84.3	5.7	5.1	5.1	4.7	0.0	14139	16.73	83.5	3.7
-21	14401	16.07	84.4	6.0	16.9	0.0	5.6	0.0	14266	16.30	83.6	3.7
-22	14477	16.83	84.2	5.7	8.8	2.1	5.0	2.6	12127	16.27	83.2	3.0
-23	18815	16.80	84.2	5.3	33.3	7.7	5.6	0.0	14637	16.37	83.4	2.7
-24	16360	17.30	84.5	4.7	8.3	4.2	4.6	4.2	11876	16.63	84.3	3.3

EVALUATION OF HALF-SIB PROGENIES FROM POPN-FC123, SALINAS, CA, 2002

	Test 4402 (Yield)				Test 1202 (NB)				Test 5802 (CLS)			
Variety	Sugar Yield lbs/a	Sucrose %	RJAP %	PM Score	Bolt % 9/4	DM 4/3	PM Mean	Root Rot %	Sugar Yield lbs/a	Sucrose %	RJAP %	CLS Score Mean
01-FC123-25	16551	17.40	85.0	5.3	0.0	0.0	3.6	0.0	11420	16.20	83.7	2.7
-26	16549	17.50	82.2	5.7	38.4	0.0	4.3	0.0	12979	16.40	83.3	2.7
-27	16325	17.00	83.1	4.7	21.1	8.9	5.3	3.3	13480	16.60	83.6	4.0
-28					11.9	2.6	4.3	0.0	11926	16.77	85.5	3.3
-29	16026	16.97	85.0	5.0	11.1	3.3	5.7	3.3	18589	17.63	85.9	2.0
-30	15206	16.57	84.3	4.3	8.9	0.0	4.3	0.0	13467	17.70	85.4	3.7
-31	18664	17.63	84.4	5.7	51.6	2.8	7.1	0.0	13921	16.43	84.4	3.0
01-FC123-32	16692	17.70	83.5	3.7	15.0	0.0	4.6	0.0	13592	15.87	83.7	2.3
Mean	15787.2	16.65	84.5	5.2	15.8	14.4	4.3	4.0	12644.8	16.54	83.6	2.9
LSD (.05)	3394.4	1.18	3.2	1.1	19.6	27.3	1.2	13.2	3766.5	1.22	4.4	1.1
C.V. (%)	13.2	4.33	2.3	12.6	76.1	116.3	16.4	201.1	18.3	4.52	3.2	23.4
F value	1.6NS	1.64*	1.7*	2.9**	3.8**	2.5**	6.3**	1.0NS	2.4**	2.19**	0.8NS	2.6**

EVALUATION OF HALF-SIB PROGENIES FROM POPN-FC1014, SALINAS, CA, 2002

| Variety | Test 4502 (Yield) | | | | | Test 1302 (NB) | | | Test 5702 (CLS) | | | |
	Sugar Yield lbs/a	Sucrose %	RJAP %	PM Score	Bolt %	Bolt 9/4 %	DM 4/3	PM Mean	Sugar Yield lbs/a	Sucrose %	RJAP %	CLS Score Mean
01-FC1014 - 1	16308	16.30	84.4	4.7	4.2	64.3	5.3	5.3	18544	16.83	84.2	1.0
- 2	16535	17.47	84.3	4.7	1.8	75.6	16.7	5.8	15974	17.80	82.8	2.0
- 3	13840	16.37	83.1	5.7	0.0	78.8	5.1	7.1	15146	17.20	84.0	2.0
- 4	15672	17.23	85.2	5.0	0.0	59.5	12.8	5.6	14872	17.50	83.8	2.0
- 5	13941	16.93	83.0	5.0	0.0	43.3	32.8	4.3	14915	17.13	83.5	1.7
- 6	14873	17.17	84.8	6.3	0.0	15.1	15.4	5.7	14038	17.13	82.2	2.0
- 7	15561	17.30	82.8	4.3	0.0	26.9	17.9	5.7	12760	16.20	86.7	1.3
- 8	13582	15.90	81.4	4.3	0.0	12.3	12.3	4.8	13936	16.90	82.6	1.7
- 9	13238	15.73	85.5	5.0	2.2	12.2	22.8	3.2	14024	16.57	82.3	1.3
-10	14483	16.90	84.6	4.3	1.9	65.7	18.7	4.8	14707	17.80	82.5	1.0
-11	16339	16.73	83.7	5.7	0.0	28.9	6.7	5.9	13505	16.47	82.3	1.7
-12	15709	16.87	85.1	6.3	2.2	64.6	14.8	5.8	15023	17.40	81.3	1.7
-13	14602	17.43	82.2	4.3	0.0	12.5	4.8	4.4	15046	17.97	83.1	1.3
-14	17438	17.03	82.9	5.0	0.0	62.2	17.9	6.7	16094	16.63	82.0	2.0
-15	13460	17.33	84.0	4.7	0.0	46.4	11.0	5.2	12590	17.40	82.3	2.0
-16	17705	17.47	86.5	6.3	1.9	72.9	7.5	6.9	15781	17.47	81.0	2.0
-17	15573	17.60	83.8	5.0	0.0	40.3	20.8	5.0	13573	17.60	79.5	1.7
-18	14104	16.70	85.4	6.3	0.0	50.0	10.2	5.9	16533	16.90	83.7	2.0
-19	12231	15.30	85.5	6.0	0.0	64.1	6.7	6.7	15791	16.80	85.1	1.3
-20	15734	17.27	84.7	6.3	2.8	56.2	13.1	7.1	15716	17.67	83.1	2.0
-21	17046	17.57	83.0	4.3	0.0	31.8	4.9	6.1	15682	17.47	84.1	2.0
-22	15475	17.97	83.3	3.3	2.1	66.7	7.1	5.2	14939	17.97	81.9	1.7
-23	14215	16.23	79.8	4.3	7.4	72.1	13.5	5.9	12907	16.27	82.7	1.3
01-FC1014 -24	15389	17.17	83.3	5.0	2.1	37.8	0.0	5.1	14250	17.10	83.7	2.0

EVALUATION OF HALF-SIB PROGENIES FROM POPN-FC1014, SALINAS, CA, 2002

(cont.)

Variety	Test 4502 (Yield)					Test 1302 (NB)			Test 5702 (CLS)			
	Sugar Yield lbs/a	Sucrose %	RJAP %	PM Score	Bolt %	Bolt 9/4 %	DM 4/3	PM Mean	Sugar Yield lbs/a	Sucrose %	RJAP %	CLS Score Mean
01-FC1014 -25	15004	17.30	84.2	3.7	0.0	41.0	8.9	5.8	15170	15.67	78.7	2.0
-26	15389	18.23	82.9	3.0	0.0	31.6	2.6	5.7	16022	17.97	83.1	1.7
-27	15869	17.43	81.9	5.0	0.0	28.4	5.6	5.4	13292	17.07	79.6	1.7
-28	16692	18.30	83.9	2.7	4.4	41.1	14.4	4.9	17715	17.73	81.3	1.0
-29	14757	17.27	84.7	3.7	0.0	74.4	24.4	5.6	15212	17.17	82.9	1.3
-30	15904	17.27	83.4	3.0	0.0	47.5	14.8	4.8	14867	17.87	84.2	1.3
-31	14259	16.10	82.1	4.7	0.0	18.3	10.7	4.4	12368	16.10	80.2	1.3
01-FC1014 -32	14957	17.50	85.0	4.0	0.0	11.0	16.0	5.6	14269	16.80	84.7	1.0
Mean	15183.9	17.04	83.8	4.8	1.0	45.4	12.4	5.5	14851.9	17.14	82.7	1.6
LSD (.05)	3177.2	1.25	3.6	1.5	4.4	22.0	18.8	1.2	3798.0	1.39	3.9	0.7
C.V. (%)	12.8	4.49	2.7	19.0	261.8	29.7	93.0	13.2	15.7	4.96	2.9	25.6
F value	1.3NS	2.42**	1.2NS	3.9**	1.3NS	7.7**	1.1NS	4.1**	1.1NS	1.49NS	1.5NS	2.2**

Variety	Test 4602 (Yield)				Test 1402 (NB)			
	Sugar Yield	Sucrose	RJAP	PM	% Bolt	DM	PM	Root Rot
	lbs/a	%	%	Score	9/4	4/3	Mean	%
Checks								
1833-5	12681	17.43	82.2	5.3	2.6	3.0	4.0	0.0
Half-sibs from 869								
1869 - 1	16953	16.50	85.4	5.3	30.6	1.0	4.6	0.0
- 2	16285	15.77	86.2	5.7	13.0	2.7	4.1	0.0
- 3	19064	16.33	87.5	6.0	30.0	2.0	4.1	4.2
- 4	19192	17.10	85.4	7.3	30.3	2.7	6.1	3.3
- 5	15911	16.37	87.6	4.7	15.9	1.0	4.8	13.5
- 6	16286	16.20	87.4	6.0	55.9	0.3	5.6	2.1
- 7	16885	15.13	87.2	6.3	43.8	0.3	5.1	0.0
- 8	16199	15.97	86.1	6.7	34.6	0.3	4.6	3.0
- 9	17948	16.07	86.5	6.3	24.4	0.7	5.9	0.0
-10	17675	16.47	88.1	6.0	37.6	0.7	6.1	2.6
-11	16756	16.40	87.9	5.3	38.8	0.7	5.4	4.9
-12	16456	15.23	85.3	7.0	12.1	1.7	6.9	7.1
-13	21138	16.63	88.2	6.7	42.9	1.7	5.3	0.0
-14	16981	16.67	87.9	6.7	33.6	2.7	6.8	2.6
-15	14766	15.73	86.4	6.7	0.0	1.0	6.6	4.4
-16	16579	16.80	85.1	6.3	20.4	0.7	6.2	0.0
-17	15283	15.93	86.3	5.7	12.9	0.3	5.8	3.0
-18	14699	16.37	87.6	6.0	34.4	0.3	6.0	0.0
-19	16616	16.80	87.1	4.3	32.3	0.3	4.6	2.8
-20	17635	16.37	86.3	5.7	0.0	1.0	5.0	12.1
-21	17982	15.27	86.0	4.7	4.2	2.0	3.8	0.0
-22	15026	16.83	86.3	4.7	21.7	0.3	4.8	0.0
-23	17150	16.10	84.5	5.7	3.0	3.0	5.8	3.0
-24	18397	17.03	87.2	6.0	5.6	0.7	4.2	0.0
-25	19908	16.60	86.5	5.7	30.3	1.3	6.0	2.6
-26	16628	15.83	83.9	7.0	15.2	1.7	6.3	0.0
-27	18220	16.93	88.3	6.0	20.3	1.7	5.2	0.0
-28	15486	15.57	83.8	6.0	16.8	2.7	6.0	17.9
-29	19345	16.00	85.7	5.3	35.3	1.3	5.8	0.0
-30	17170	17.13	87.0	4.7	8.9	0.7	6.3	4.2
Mean	17021.9	16.34	86.3	5.9	22.1	1.3	5.3	2.9
LSD (.05)	2827.4	1.04	4.0	1.4	23.6	1.9	1.2	8.9
C.V. (%)	10.2	3.88	2.8	14.4	65.5	89.1	13.9	186.1
F value	2.9**	2.64**	1.0NS	2.4**	3.2**	1.8*	4.9**	1.9*

EVALUATION OF HALF-SIB PROGENIES OF Z25, SALINAS, CA, 2002

Variety	Test 3902 (VY)				Test 1502 (NB)		
	Sugar Yield	Sucrose	RJAP	Powdery Mildew	% Bolting	Downey Mildew	Powdery Mildew
	Lbs	%	%	Score	9/04	4/05	Mean
Checks							
1930-19	8558	17.10	85.5	1.3	0.0	4.3	2.3
1930-35A	14932	18.17	84.1	2.3	12.4	2.7	3.8
Z025	18109	17.73	83.7	3.7	53.6	2.0	5.0
Z025-9	12817	17.23	80.0	1.0	35.8	2.3	3.7
Z131-14	2552	15.33	84.1	2.3	7.9	4.3	2.7
Z131-18	4971	17.83	82.3	1.0	4.8	2.3	3.3
Half-sibs of Z25							
Z125 - 1	16884	17.20	84.3	3.7	43.6	5.3	5.1
- 2	15079	16.80	82.9	3.7	2.6	6.7	4.7
- 3	15316	15.50	86.0	3.0	49.8	4.0	5.4
- 4	16747	16.43	85.6	3.3	39.4	5.0	5.3
- 5	15803	15.80	87.8	4.0	53.7	5.3	5.1
- 6	13450	16.63	83.8	4.0	10.2	6.7	5.0
- 7	17098	17.90	87.2	4.3	32.5	4.7	4.8
- 8	15455	15.97	82.4	4.0	40.3	7.7	4.1
- 9	17592	16.10	86.6	4.3	5.8	9.0	4.1
-10	17212	16.57	85.3	4.3	76.8	3.3	4.4
-11	14625	14.90	83.1	3.3	27.3	9.3	4.3
-12	15021	16.00	85.1	3.7	51.0	4.7	4.1
-13	19467	17.33	84.3	3.7	23.8	6.0	5.4
-14	16623	16.10	83.3	5.0	34.2	6.0	5.8
-15	15586	16.73	84.7	5.0	68.3	3.7	5.2
-16	21721	17.30	84.1	4.7	59.9	3.7	5.9
-17	18842	16.63	82.5	5.3	42.0	6.7	5.8
-18	18793	17.33	85.0	5.0	73.2	4.3	5.9
-19	20088	18.03	83.7	4.7	67.5	4.3	5.3
-20	18527	17.30	84.9	4.7	76.4	4.3	5.4
-21	17689	16.47	83.9	3.7	60.3	5.7	4.3
-22	15440	17.60	85.1	4.7	40.1	7.0	5.6
-23	16988	16.97	85.0	3.7	67.0	5.3	4.9
-24	17166	17.23	84.6	3.0	35.4	2.3	5.0
-25	19481	18.60	88.0	3.7	46.2	4.0	5.0
-26	20776	18.40	86.4	4.7	22.6	5.0	5.6
-27	18039	16.83	84.2	5.3	74.1	4.0	6.1
-28	17983	17.43	86.3	3.0	34.6	2.7	4.8
-29	19507	18.23	84.8	5.0	45.1	3.0	4.1
-30	18285	17.17	83.9	4.3	16.0	3.7	5.4
-31	17250	17.00	85.0	5.0	46.8	3.7	5.1
-32	17362	16.27	85.5	3.3	35.0	4.3	5.4
-33	20207	17.70	82.3	3.3	24.5	3.0	4.4

A200

	Test 3902 (VY)				Test 1502 (NB)		
Variety	Sugar Yield	Sucrose	RJAP	Powdery Mildew	% Bolting	Downey Mildew	Powdery Mildew
	Lbs	%	%	Score	9/04	4/05	Mean

Half-sibs of Z25 (cont.)

Variety	Lbs	%	%	Score	9/04	4/05	Mean
Z125 -34	19271	18.17	83.6	4.0	42.3	3.0	5.6
-35	16552	18.13	84.9	2.3	35.1	1.7	4.8
-36	18270	17.13	86.2	2.7	60.3	4.3	5.1
-37	19782	17.97	82.8	3.7	38.3	1.7	5.0
-38	19922	16.60	84.6	5.0	44.7	2.7	5.8
-39	18769	16.77	85.4	4.3	28.0	3.7	5.2
-40	19142	17.20	84.5	5.7	21.6	2.7	5.4
-41	16245	17.43	85.6	3.0	22.6	2.3	4.4
-42	19145	18.20	82.9	2.7	54.0	1.0	5.3
-43	20052	17.37	86.3	5.0	62.2	2.7	6.2
-44	17818	17.00	84.0	5.0	33.9	5.3	5.7
-45	16488	16.73	85.9	4.7	39.2	5.0	5.4
-46	18222	17.13	83.2	5.0	17.7	2.7	5.6
-47	18727	16.97	86.3	5.0	67.5	2.0	5.2
-48	17484	16.10	82.9	5.0	30.4	5.7	5.6
-49	17530	16.37	85.1	2.3	21.0	5.3	4.9
-50	19612	18.17	85.0	3.0	36.1	2.7	4.7
-51	18068	16.53	84.6	1.3	24.4	5.7	3.7
-52	18278	17.33	80.9	2.7	38.9	3.3	4.9
-53	21042	18.70	85.9	5.0	69.0	1.0	5.1
-54	18379	16.70	87.1	4.0	35.1	2.7	4.4
-55	20471	18.20	85.9	2.7	40.6	0.3	5.2
-56	18328	17.63	85.9	3.3	19.7	2.3	5.4
-57	17002	17.63	85.3	3.7	41.3	2.7	5.7
-58	13257	16.33	81.4	5.0	22.5	8.0	5.4
-59	17980	15.93	81.2	3.0	47.1	2.3	5.1
-60	16451	17.67	87.3	2.0	41.7	1.0	5.1
-61	18637	17.20	85.9	4.3	60.8	2.7	6.6
-62	22665	17.80	84.6	4.0	26.1	1.3	5.8
-63	21180	17.77	83.8	3.3	73.1	2.7	5.2
-64	19752	17.00	84.4	4.0	40.2	3.7	6.0
-65	19825	17.87	85.3	4.0	16.4	2.0	4.6
-66	20634	17.63	83.4	4.7	71.8	3.7	6.7
-67	17308	17.30	82.1	4.7	32.1	2.0	5.8
-68	17765	17.13	86.1	3.0	23.1	2.7	5.8
-69	18709	17.87	86.2	3.0	43.8	0.3	5.9
-70	19720	18.00	85.7	4.7	63.6	1.7	6.1
-71	19375	18.73	86.8	5.3	52.2	2.7	6.6
Z125 -72	18898	18.20	86.0	3.3	50.0	0.7	5.1

A201

	Test 3902 (VY)				Test 1502 (NB)		
	Sugar			Powdery	%	Downey	Powdery
Variety	Yield	Sucrose	RJAP	Mildew	Bolting	Mildew	Mildew
	Lbs	%	%	Score	9/04	4/05	Mean
Half-sibs of Z25	(cont.)						
Z125 -73	16492	17.07	82.0	4.0	52.4	2.7	5.6
-74	16279	16.00	82.6	4.0	50.9	3.7	5.6
-75	19211	17.60	84.7	4.7	24.1	3.3	5.7
-76	19764	17.03	85.0	3.7	34.8	5.3	5.4
-77	19200	18.43	85.3	3.3	65.4	3.7	4.8
-78	19586	18.30	85.5	5.0	31.7	2.7	6.0
-79	16263	16.20	84.2	3.7	55.9	1.7	5.1
-80	23132	18.53	86.6	3.0	53.2	1.3	4.9
-81	18774	17.63	85.5	4.3	77.1	3.3	6.6
-82	21256	17.47	84.2	3.7	49.7	1.0	6.0
-83	17206	17.80	84.4	1.0	36.8	1.7	5.0
-84	21283	18.00	85.7	2.3	24.2	1.3	4.1
-85	18834	18.03	85.7	2.7	56.7	1.0	4.9
-86	18565	16.67	85.8	4.3	5.6	2.7	5.1
-87	20139	17.83	84.1	4.0	75.2	4.3	5.1
-88	19199	18.13	86.4	4.3	83.3	4.3	4.9
-89	18748	18.07	84.4	5.3	41.7	2.0	5.2
Z125 -90	19314	18.03	84.6	5.0	47.2	2.0	5.1
Mean	18104.6	17.26	84.7	3.8	41.6	3.5	5.1
LSD (.05)	3335.6	1.29	3.6	1.6	26.0	3.6	1.0
C.V. (%)	11.4	4.64	2.7	26.0	38.7	62.9	12.4
F value	2.9**	3.05**	1.4*	3.5**	4.4**	2.1**	4.3**

EVALUATION OF S_1 PROGENIES OF Z25,941 and 931,   SALINAS, CA, 2002

| Variety | Test 4002 (Yield) | | | | Test 802 (NB) | | | |
| | Sugar Yield | Sucrose | RJAP | PM | Bolt | DM | PM | Root Rot |
	lbs/a	%	%	Score	%	4/3	Mean	%
Checks								
1931(Iso)	18386	16.90	83.9	3.0	9.4	6.7	4.9	0.0
1941(Iso)	17072	16.97	85.0	3.7	8.9	3.7	4.8	0.0
Z125	18229	17.37	83.4	3.7	47.4	4.0	5.0	0.0
Z025-9	16144	19.13	82.7	1.0	20.0	2.3	3.4	0.0
0930-19	16544	17.10	86.2	1.7	2.4	8.0	2.8	0.0
1930-19	15649	16.60	84.5	1.3	0.0	8.0	2.4	0.0
1930-35A	13028	17.73	83.1	3.0	45.2	3.3	3.6	0.0
S_1's from Z25								
Z125 -101	12122	16.70	84.4	2.3	8.3	4.0	2.4	0.0
-102	17278	15.37	81.7	3.0	40.6	3.3	4.2	0.0
-103	13977	16.43	83.4	5.3	29.5	2.3	4.8	0.0
-104	16597	16.40	85.4	2.3	43.7	3.7	3.4	0.0
-105	15715	18.03	83.1	3.3	40.0	1.7	5.7	0.0
-106	14218	16.87	83.6	0.3	81.5	0.3	1.9	0.0
-107	15024	15.93	83.0	2.0	55.0	5.0	3.7	0.0
-108	14512	16.60	83.8	1.0	69.4	4.3	3.4	0.0
-109	13119	17.33	83.9	3.3	3.7	5.7	2.1	0.0
-110	12913	15.70	82.8	2.3	0.0	6.3	2.4	0.0
-111	13190	17.17	83.4	3.7	83.1	3.3	3.8	0.0
-112	15177	16.93	85.0	5.3	22.6	4.0	4.1	0.0
-113	13698	15.07	86.1	3.3	97.2	10.0	5.4	0.0
-114	14912	17.13	85.7	2.3	29.1	3.7	3.6	0.0
-115	14405	17.63	85.5	2.0	22.8	1.7	3.8	2.6
-116	12169	15.07	80.9	2.0	28.3	4.3	3.3	0.0
1941	18091	17.00	85.1	4.0				
1941 -102	16309	15.63	84.5	3.0	19.7	5.7	2.8	0.0
-103	13323	15.03	81.0	1.3	8.3	10.0	2.9	0.0
-104	13785	15.37	82.8	1.0	36.2	5.0	3.7	3.0
-105	14746	16.73	86.4	1.0	60.4	1.3	3.7	0.0
-106	15423	16.03	82.9	0.0	21.2	7.3	2.6	0.0
-107	15830	17.23	85.0	5.7	0.0	1.3	6.4	0.0
-108	14515	15.07	88.2	3.3	58.5	1.7	4.4	0.0
-109	12161	17.07	81.9	1.7	47.9	2.3	3.9	0.0
-110	17544	17.40	84.7	0.0	61.3	5.0	1.4	0.0
-111	16777	15.87	85.8	3.7	32.4	5.7	5.4	0.0
-112	16191	18.43	84.7	0.0	31.4	0.3	2.1	0.0
-113	15164	17.20	83.2	0.7	21.2	3.0	1.7	0.0
-114	16850	17.40	83.1	3.0	11.4	0.3	3.3	0.0

EVALUATION OF S$_1$ PROGENIES OF Z25,941 and 931,   SALINAS, CA, 2002

	Test 4002 (Yield)				Test 802 (NB)			
Variety	Sugar Yield	Sucrose	RJAP	PM	Bolt	DM	PM	Root Rot
	lbs/a	%	%	Score	%	4/3	Mean	%

S$_1$'s from Z25 (cont.)

Variety	Sugar Yield	Sucrose	RJAP	PM	Bolt	DM	PM	Root Rot
1941 -115	12073	16.53	79.9	2.3	19.4	5.0	3.3	0.0
-116	13590	16.77	86.5	5.3	61.8	4.0	6.6	0.0

S$_1$'s from 931

Variety	Sugar Yield	Sucrose	RJAP	PM	Bolt	DM	PM	Root Rot
1931 -101	17620	16.87	87.9	2.3	19.8	3.0	4.3	5.1
-102	16950	16.77	87.2	4.3	0.0	4.3	5.1	3.0
-103	15494	15.93	82.0	4.0	14.4	2.0	3.0	0.0
1931 -104	13862	15.63	82.9	3.3	0.0	1.7	3.2	0.0
1931	19435	16.07	84.5	3.0				
1931 -105					100.0	0.7	5.1	0.0
1931 -106	16524	16.37	83.7	3.3	21.8	1.0	4.9	0.0
-107	17153	16.30	83.7	1.0	51.1	1.7	4.9	0.0
-108	14511	16.30	84.3	0.0	55.8	3.0	2.2	0.0
1931 -109	13644	15.03	85.0	2.0	0.0	4.7	4.9	0.0
-110	14398	15.60	84.2	3.3	18.2	3.7	3.6	0.0
-111	14384	14.77	82.7	3.7	0.0	3.3	5.0	0.0
-112	13758	15.37	84.8	3.0	70.8	2.0	5.6	0.0
-113	13075	14.77	81.1	4.7	51.0	3.3	6.2	0.0
-114	15751	16.07	87.1	4.3	59.0	2.0	4.4	0.0
-115	14718	17.00	85.2	2.7	85.2	3.7	4.6	0.0
-116	13108	14.67	81.8	2.3	0.0	2.0	1.8	0.0
-117	15230	16.67	85.7	3.0	21.4	0.7	4.9	0.0
-118	16179	16.23	87.0	4.0	37.2	2.7	6.0	0.0
-119	15040	15.87	79.6	1.7	40.7	3.3	3.4	3.7
1931 -120	16972	17.10	83.4	2.7	8.8	4.3	4.7	0.0
1931	19753	16.33	85.0	2.0				

Checks

Variety	Sugar Yield	Sucrose	RJAP	PM	Bolt	DM	PM	Root Rot
1929-62	16356	15.60	83.7	1.7	2.1	3.7	3.0	0.0
1929-4	16717	17.70	84.7	2.3	25.9	1.7	4.0	0.0
1924-4	14395	17.43	85.8	1.0	19.4	5.0	4.1	14.9
Mean	15326.1	16.48	84.1	2.6	33.3	3.6	4.0	0.6
LSD (.05)	3860.9	1.53	3.5	1.6	22.4	3.7	1.2	4.9
C.V. (%)	15.6	5.73	2.6	38.9	41.7	63.6	18.4	539.8
F value	1.8**	3.03**	2.1**	5.7**	11.4**	2.7**	9.4**	1.5*

EVALUATION OF S$_1$ PROGENIES OF 933, SALINAS, CA, 2002

	Test 4102 (Yield)				Test 902 (NB)				Test 6102 (CLS)			
Variety	Sugar Yield lbs/a	Sucrose %	RJAP %	PM Score	% Bolt 9/4	DM 4/3	PM Mean	Root Rot %	Sugar Yield lbs/a	Sucrose %	RJAP %	CLS Score Mean
Checks												
Z025-9	15742	18.63	81.7	1.0					14596	18.80	82.3	3.3
1933	20613	17.50	85.1	4.7	9.3	6.3	4.8	2.1	18234	16.63	84.9	2.7
01-SP22-0					91.1	6.7	6.0	8.9				
S$_1$'s from 933												
1933 -101	14642	16.67	84.1	5.3	2.8	7.7	4.3	0.0	10865	13.13	75.6	3.7
-102	15679	16.17	83.4	3.7	11.1	4.0	3.8	0.0	16467	16.57	82.6	4.3
-103	13666	16.67	82.8	2.7	0.0	2.3	1.7	3.7	10472	15.27	81.9	3.7
-104	20750	16.37	86.1	3.7	8.2	4.7	4.0	0.0	17096	15.07	80.0	3.0
-105	12796	16.67	80.9	4.0	0.0	1.7	3.1	0.0	8560	14.97	79.6	3.3
-106	19974	17.27	85.0	2.7	14.0	4.3	2.2	0.0	17313	16.47	83.2	3.0
-107	15822	16.13	84.4	2.3	0.0	1.7	1.1	0.0	14836	16.40	83.3	1.3
-108	20611	15.87	85.8	5.7	0.0	9.0	5.3	0.0	9633	11.53	76.6	4.7
-109	16456	16.57	84.0	5.7	9.8	9.7	6.7	0.0	13329	15.40	83.4	5.0
-110	17247	15.77	84.6	5.3	2.8	8.7	7.1	0.0	16231	14.60	81.5	3.7
-111	12347	14.60	82.8	1.7	2.4	5.7	2.1	0.0	11455	15.33	82.1	4.3
-112	12965	14.37	81.6	0.0	18.2	7.0	1.6	0.0	10096	12.07	76.8	3.3
-113	17289	16.60	84.8	3.3	16.1	2.0	5.0	0.0	15382	16.20	82.5	1.3
-114	15244	15.00	84.8	4.7	0.0	10.0	5.2	0.0	8524	12.37	77.1	4.0
-115	17607	15.73	84.8	3.7	53.2	6.7	4.9	0.0	13843	15.93	82.3	4.0
-116	15689	15.77	83.6	2.7	4.8	5.0	4.7	0.0	12265	15.70	82.8	3.0
-117	17046	15.20	82.8	2.7	8.8	3.7	3.4	0.0	13335	14.10	78.3	2.7
-118	18424	16.73	84.9	4.0	8.9	1.3	5.4	0.0	20886	17.27	86.6	2.0
-119	14899	15.23	84.2	2.3	21.8	2.0	2.2	0.0	9829	13.80	82.0	3.0
-120	15899	15.70	83.8	4.7	0.0	1.0	5.2	0.0	13762	13.87	81.9	4.7
-121	16336	17.07	84.2	0.7	25.6	3.3	2.1	0.0	13188	16.50	79.8	3.0
-122	13830	14.00	84.2	5.3	0.0	3.7	5.4	5.0	7779	11.43	78.0	4.7

EVALUATION OF S$_1$ PROGENIES OF 933, SALINAS, CA, 2002

(cont.)

	Test 4102 (Yield)				Test 902 (NB)				Test 6102 (CLS)			
Variety	Sugar Yield lbs/a	Sucrose %	RJAP %	PM Score	Bolt 9/4 %	DM 4/3	PM Mean	Root Rot %	Sugar Yield lbs/a	Sucrose %	RJAP %	CLS Score Mean
S$_1$'s from 933 (cont.)												
1933 -123	17111	15.23	85.1	4.0	19.3	1.0	4.9	0.0	13290	15.07	81.9	3.3
-124	14142	14.70	85.2	5.0	0.0	4.0	5.2	0.0	11381	13.77	81.3	4.0
-125	15305	16.50	84.6	4.7	2.8	0.3	4.9	0.0	15088	16.47	87.0	2.3
-126	14857	14.57	85.1	5.3	63.7	0.3	5.0	0.0	11603	13.90	82.2	2.3
-127	17592	16.47	83.1	5.7	6.9	3.3	6.1	0.0	11218	13.50	79.9	2.7
-128	14867	15.93	80.3	4.0	19.4	1.0	3.7	0.0	14054	17.43	81.2	3.3
-129	15787	14.10	83.3	3.7	24.8	5.0	5.0	0.0	13647	14.33	81.3	3.3
-130	18235	17.70	85.1	2.0	20.5	0.7	3.6	0.0	16732	17.47	87.2	2.7
Mean	16233.5	15.98	84.0	3.7	14.6	4.2	4.2	0.6	13280.9	15.04	81.5	3.3
LSD (.05)	3117.9	1.90	4.2	1.7	19.5	4.5	1.0	3.8	3494.4	2.10	5.0	1.3
C.V. (%)	11.8	7.29	3.1	28.3	82.1	166.5	14.0	378.5	16.1	8.55	3.7	24.3
F value	4.1**	2.64**	0.9NS	6.7**	8.6**	3.2**	20.7**	2.0*	6.3**	5.93**	2.6**	3.9**

EVALUATION OF S₁ PROGENIES OF 921 and 934, SALINAS, CA, 2002

	Test 4202 (VY)				Test 1002 (NB)		
Variety	Sugar Yield	Sucrose	RJAP	Powdery Mildew	% Bolting	Downey Mildew	Powdery Mildew
	Lbs	%	%	Score	9/04	4/05	Mean
Checks							
1927-4	15422	16.30	85.8	5.0	40.3	4.7	6.1
Y167	20280	16.33	82.6	4.0	49.8	2.7	4.6
0921	19180	16.67	83.2	4.7	61.6	8.7	4.9
S₁'s from 921							
1921 -101	18129	16.27	87.5	4.3	67.3	5.3	5.4
-102	14788	17.17	82.9	5.0	5.6	9.3	4.9
-103	18769	17.07	83.7	4.7	73.7	2.7	4.6
-104	16158	16.97	85.4	3.3	36.5	2.3	5.2
-105	16872	15.50	84.4	3.7	59.6	7.0	3.4
-106	15797	16.13	83.0	3.3	86.5	2.0	5.4
-107	15188	16.17	79.2	5.7	20.6	2.7	2.3
-108	20386	17.47	86.4	3.3	52.4	2.7	2.4
-109	15245	15.97	83.9	3.3	84.1	1.7	3.6
-110	15100	16.67	81.2	4.3	81.7	2.7	7.4
-111	15585	15.60	81.3	3.3	00.0	2.7	6.1
-112	15583	16.40	82.3	5.7	49.0	4.0	7.0
-113	14135	15.23	82.6	3.0	0.0	6.7	2.4
-114	13242	14.97	84.9	2.0	44.6	3.7	3.8
-115	11859	15.83	80.9	2.0	88.1	2.7	4.4
-116					49.1	3.3	5.0
Y175-13	16762	16.50	81.5	4.3			
S₁'s from 934							
1934 -101	15630	15.37	79.9	4.3	39.9	4.7	4.9
-102	15371	16.80	87.5	6.7	5.6	5.3	7.6
-103	16265	16.57	83.5	4.7	39.7	3.0	4.4
-104	16684	16.27	80.3	4.3	28.8	3.3	5.3
-105	17639	18.00	83.6	3.0	45.7	1.0	4.3
-106	16597	17.43	81.2	6.3	20.4	0.3	6.7
-107	14716	16.07	83.3	3.3	3.0	3.0	4.9
-108	17739	15.70	85.1	3.7	73.7	3.3	5.6
-109	14004	14.50	84.1	5.7	0.0	0.7	5.7
-110	19496	16.37	85.6	3.0	10.4	2.7	3.6
-111	15812	15.83	83.8	3.0	20.2	7.3	5.1
-112	9260	16.07	80.6	4.7	0.0	5.3	4.8
-113	17285	16.80	79.5	2.0	15.8	2.7	4.1
Mean	16093.1	16.28	83.2	4.1	42.3	3.8	4.9
LSD (.05)	3682.5	1.10	3.1	1.5	23.2	3.3	1.4
C.V. (%)	14.0	4.13	2.3	22.9	33.7	154.1	17.8
F value	3.2**	3.73**	4.0**	5.0**	13.0**	3.5**	6.8**

SUGAR BEET RESEARCH
USDA-ARS Sugarbeet Research Unit in Fort Collins, Colorado

2002 REPORT

Section B

U.S. Department of Agriculture, Agricultural Research Service
Northern Plains Area, (USDA-ARS-NPA)
Crops Research Laboratory, Sugar Beet Research Unit
1701 Centre Ave.; Fort Collins, CO. 80526-2083

Phone: (970) 498-4204
Fax: (970) 482-2909
Email: lpanella@lamar.colostate.edu
Web access: http://www.crl.ars.usda.gov/

Dr. Lee Panella, Geneticist & Research Leader
Dr. Susan S. Martin, Plant Physiologist (retired)
Dr. Linda E. Hanson, Plant Pathologist

Cooperation:

Colorado Agricultural Experiment Station

_____

USDA-ARS-NPA Sugar Beet Research Unit's Mission Statement

Utilize distinctive site environmental and disease-free characteristics and specifically developed team expertise to: develop new knowledge and adapt biotechnologies to modify host-pathogen relations that affect disease resistance, pathogenesis, and epidemiology in sugar beet and other plant species pertinent to sugar beet cultivation; discover new information and techniques to identify and produce genotypes exhibiting superior disease and stress tolerance and agronomic qualities; and provide new knowledge that improves production efficiency and biochemical processing characteristics of sugar beet.

CONTENTS

PUBLICATIONS

1. Caolo-Tanski, Janet M., Linda E. Hanson, Amy L. Hill and Joseph P. Hill. The potential use of Australian "tea tree oil" (*Melaleuca alternifolia*) as a method of control for several plant pathogens. Proceedings of the 6th annual Rocky Mountain Plant Biotechnology and Molecular Biology Symposium. pg. 22. 2002. (Abstract)

2. Caolo-Tanski, J.M., L.E. Hanson, A.L. Hill and J.P. Hill. Use of *Melaleuca alternifolia* oil for plant disease control. Phytopathology. 92:S12. 2002.(Abstract)

3. Hanson, L.E. Biological control of sugar beet damping-off with *Trichoderma* species. Phytopathology. 92:S33. 2002. (Abstract)

4. Hanson. L.E. and C.R. Howell. Biocontrol efficacy and other characteristics of protoplast fusants between *Trichoderma koningii* and *T. virens*. Mycological Research. 106:321-328. 2002.

5. Hanson, Linda E., Chris Lawrence and Slavica Djonivic. Mechanisms of biological control of plant diseases with *Trichoderma*. Proceedings of the 6th annual Rocky Mountain Plant Biotechnology and Molecular Biology Symposium. pg. 2. 2002.

6. Hanson, L. E., S. S. Martin, and L. Panella. Disease Nurseries ... A tool to evaluate resistance. The Sugar Producer Magazine, pp. 20-21, January, 2002. (popular press).

7. Hanson, L.E. and L. Panella. *Beta* PIs form the USDA-ARS NPGS evaluated for resistance to *Cercospora beticola*, 2001. Biological and Cultural Tests for Control of Plant Diseases. 17:F03. DOI: 10.1094/BC17. The American Phytopathological Society, St. Paul, MN. 2002

8. Hanson, L.E. and L. Panella. Evaluation of *Beta* PIs from the USDA-ARS NPGS for resistance to curly top virus, 2001. Biological and Cultural Tests for Control of Plant Diseases. 17:F04. DOI: 10.1094/BC17. The American Phytopathological Society, St. Paul, MN. 2002.

9. Hanson, L.E. and L. Panella. Rhizoctonia root rot resistance of *Beta* PIs from the USDA-ARS NPGS, 2001. Biological and Cultural Tests for Control of Plant Diseases. 17:F05. DOI: 10.1094/BC17. The American Phytopathological Society, St. Paul, MN. 2002.

10. Hill, A.L., R. Gutierrez and L.E. Hanson. Isolation of a beta-tubulin gene fragment from *Cercospora beticola*. Proceedings of the 6th annual Rocky Mountain Plant Biotechnology and Molecular Biology Symposium. pg. 14. 2002.

11. Panella, L. and L.E. Hanson. USDA-ARS sugar beet germplasm developed in Fort Collins, CO, evaluated for Rhizoctonia resistance, 2001. Biological and Cultural Tests for Control of Plant Diseases. 17:F06. DOI: 10.1094/BC17. The American Phytopathological Society, St. Paul, MN. 2002.

12. Panella, L., M. Brownson, C. Richards, S.E. Mitchell, S. Kresovich. Microsatellite Marker Development for Sugar Beet. Final Abstracts Guide - Plant, Animal and Microbe Genomes X Conference, San Diego, CA, January 12 - 16. W306, p.74. 2002.

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
WASHINGTON, DC

AND

BEET SUGAR DEVELOPMENT FOUNDATION
DENVER, COLORADO

NOTICE OF RELEASE OF FC724 MONOGERM, O-TYPE SUGARBEET GERMPLASM

The USDA Agricultural Research Service (ARS), in cooperation with the Beet Sugar Development Foundation (BSDF), announces the release of FC724 sugarbeet germplasm. This germplasm was developed in the breeding program of Drs. L. Panella and L. E. Hanson, USDA-ARS, Fort Collins, Colorado. FC724 has high resistance to root-rotting strains (AG-2-2) of *Rhizoctonia solani* Kühn and good to moderate resistance to cercospora leaf spot caused by *Cercospora beticola* Sacc., but is curly top susceptible. FC724 is an attempt to develop a population from which to select Rhizoctonia resistant monogerm O-type parents to infuse some rhizoctonia resistance on the female side of hybrids. There is no CMS equivalent. FC724 is released from seed production 961014.

FC724 is an O-type germplasm with 12% green hypoctoyls (116 plants counted) and is segregating for monogerm (*mm*). It is a product of 9 generations of cyclic mass selection for resistance to rhizoctonia root rot and 2 cycles of recurrent selection for high general combining ability. It originated from a cross of FC702 by selfed progeny lines from FC601/2 and selfed progeny lines from several leaf spot and the beet curly top virus (BCTV) resistant lines combined in 611100-0 (SLC122-0, US22/3,US201, US22/4 [SL92], SL202 [F_2 of US35/2 x US22/4]). FC601/2 consists of selected progeny lines from SL202 x SLC122-0. The original cross was approximately 20% 611100-0, 17% FC 601/2 and 63% FC702. Because the original crosses were made to male sterile plants (genetic male sterility - *aa*), it is possible that FC724 is segregating for genetic male sterility, but no male sterile plants were observed in the last seed production (961014).

Hybrid tester lines were produced with Fort Collins breeding lines to test for general combining ability in 1974 and 1977. Remnant, selfed seed from superior lines was recombined after each cycle of testing. The population has gone through 9 cycles of selection in the USDA-ARS rhizoctonia nursery in Fort Collins, has been O-type indexed to remove restorer genes from the population, and has been selected for monogerm seed throughout the development process. The smallest population size was 19 plants.

FC724 exhibited excellent resistance to rhizoctonia root rot when tested under strong disease pressure. FC724's performance was equal to or superior than the rhizoctonia-resistant checks in disease index (DI) ratings from 1998 through 2001, respectively (DI of 0 = no root rot and 7 = all plants dead). FC724 performed significantly better than the susceptible check (FC901/C817). FC724 had mean disease indices (DI=s) of 2.3, 3.1, 3.1, and 1.7 (1998-2001), whereas the highly resistant check (FC705/1) had DI=s of 2.7, 3.3, 3.1, and 1.6, respectively. Percentages of resistant plants (those rated 0 or 1) were 47, 16, 5, and 52 for FC724; 33, 22, 13, and 53 for the highly resistant check and 12, 12, 3, and 44 for the resistant check (FC703), respectively (1998-2001).

FC724 also exhibited some resistance to cercospora leaf spot when tested in an artificial epiphytotic. In two years of tests, it was significantly better than the susceptible check and not significantly different from the resistant check in one year and had significantly lower resistance than the resistant check in the other. The following DI ratings (DI of 0 = no leaf spot and 10 = all plants dead) represent the most severe rating (last of three or four ratings each season). The DIs of FC724 were 4.0 and 3.2; DIs of the resistant check (FC504CMS/FC502-2//SP6322-0) were 2.8 and 2.9; DIs of the susceptible check (SP351069-0) were 6.5 and 5.8, respectively. FC724 does not show tolerance to the BCTV.

In 2002, FC724 was yield tested for agronomic quality. One-row plots, replicated six times were planted at the USDA-ARS Crops Research Lab-Fort Collins Research Farm, CO, on May 3rd. Plots were 3.04 m long with 56 cm between rows and 20 to 25 cm within-row spacing. Roots were harvested on October 8th and sent to the tare lab of Western Sugar Co. (in Scotts Bluff, NE) for analyses. The average value of three commercial varieties - Beta 6045, HM1955, Monohikari - was used as a standard for comparison. In percent sucrose, FC724 was 96.3% of the standard and in sugar loss to molasses, FC724 was 97.9% of the standard.

Breeder seed of FC724 is maintained by USDA-ARS and will be provided in quantities sufficient for reproduction upon written request to Sugarbeet Research, USDA-ARS, Crops Research Laboratory, 1701 Center Ave., Fort Collins, CO 80526-2083. Genetic material of this release will be deposited in the National Plant Germplasm System where it will be available for research purposes, including development and commercialization of new varieties/cultivars. We request that appropriate recognition be made of the source when this germplasm contributes to a new cultivar. U.S. plant variety protection will not be requested for FC724.

Evaluation of Contributed Lines for Resistance to *Rhizoctonia solani,* a Causal Fungus of Sugar Beet Root Rot (BSDF Project 903)

L.E. Hanson and L. Panella
USDA-ARS, Fort Collins, CO

Annually, for over thirty years, the sugar beet breeding program in Fort Collins has included the production of an artificial epiphytotic through inoculation with *Rhizoctonia solani* to evaluate and select for resistance to root rot caused by this pathogen. We have been pleased to participate and lead this cooperative research project between the ARS, Colorado State University, and the BSDF.

In 2002 the project involved field studies conducted at the Crops Research Lab-Fort Collins Research Farm near Wellington, CO. Randomized, complete-block designs with five replicates were used to evaluate ARS breeding germplasm and Plant Introduction accessions. *Rhizoctonia*-resistant line FC703, highly resistant FC705-1, and highly susceptible FC901/C817 were included as internal controls.

One-row plots, planted May 23rd, were 14 feet long with 22 inches between rows and 8-10 inches within-row spacing. Inoculation with dry, ground, barley-grain inoculum of *Rhizoctonia solani* AG2-2 isolate R-9 was performed on July 17th; immediately after inoculation, a cultivation was performed so as to throw soil into the beet crowns. The field was sprayed three times with Betamix Progress (June 26, July 10 and July 22) and twice with Upbeet (June 26 and July 10) and Stinger (July 10 and 22) to control weeds. The field was thinned by hand and irrigated as necessary. Beets were harvested September 4 through 7. Each root was rated for rot on a scale of 0 to 7 (dead) as previously described. ANOVAs were performed on disease indices (DIs), percent healthy roots (classes 0 and 1 combined), and percentage of roots in classes 0 thru 3. Percentages were transformed to arcsin-square roots to normalize the data for analyses. LSDs are provided for comparing entries with those of our internal checks.

Figure 1. Summary of the weather data for 2002 Rhizoctonia root rot nursery.

The high daytime temperatures in the summer of 2002 (Figure 1), combined with a moderate inoculum load, contributed to a severe root rot epidemic. Severe disease developed by early September. Mean DIs across all tests for highly resistant FC705-1, resistant FC703, and highly susceptible FC901/C817 controls were 1.7, 2.2, and 4.4 respectively. Percentages of healthy roots were 46.5, 34.2, and 10.4% for these controls. Percentages of roots in disease classes zero thru three were 85.9, 74.1, and 29.8, respectively. The highest and lowest DIs for the evaluated lines were 6.9 and 1.3, respectively.

USDA-ARS 2002 Rhizoctonia Disease Nursery, Fort Collins, CO.

Table 1. Summary data of the entire 2002 Rhizoctonia root rot nursery. The experiment mean, the mean of the susceptible check, the mean of the resistant check, and the mean of the highly resistant check are given for each of the experiments in the nursery. LSD is at the t=0.05 level.

Exp.	Disease Index					Percent Healthy (classes 0&1)					Percent in Classes 0 to 3				
	Mean	Sus.	Res.	H. Res.	LSD	Mean	Sus.	Res.	H. Res.	LSD	Mean	Sus.	Res.	H. Res.	LSD
1R	3.8	3.1	1.9	1.4	1.3	18.7	30.5	45.5	52.7	20.3	41.1	56.5	80.0	85.6	24.3
2R	5.0	4.9	2.0	1.9	1.3	3.0	3.7	35.6	34.3	8.9	28.6	26.6	79.5	90.0	25.4
3R	3.8	4.4	2.1	1.6	1.0	15.8	11.9	44.0	50.0	15.8	42.6	28.4	67.8	88.1	19.9
4R	4.5	4.6	2.5	3.0	1.3	5.4	6.5	20.6	5.5	13.4	32.8	29.1	67.6	58.7	26.5
5R	4.7	4.7	2.0	2.2	1.1	8.1	10.0	45.8	31.2	14.5	25.2	31.1	72.3	73.3	20.7
7R	3.0	5.1	2.9	1.7	0.9	26.2	9.1	27.5	50.1	19.6	57.0	23.7	59.6	81.4	19.2
8R	3.7	4.0	2.3	1.4	1.3	11.2	12.1	20.1	44.0	16.4	42.5	35.6	79.6	90.0	27.5
11R	2.4	3.5	1.3	1.5	0.8	40.6	23.0	63.4	49.9	18.8	65.0	45.3	86.0	86.0	16.9

Percent in Classes is the transformed value (arcsin-square root)
Mean = Experiment Mean;
Sus. = Susceptible Check (FC901/C817);
Res. = Resistant Check (FC703);
H Res. = Highly Resistant Check (FC705/1)

Evaluation of Contributed Lines for Resistance to *Cercospora beticola*, Causal Fungus of Cercospora Leaf Spot (BSDF Project 904)

L.E. Hanson and L. Panella
USDA-ARS, Fort Collin, Colorado

The breeding program in Fort Collins has created an annual artificial epiphytotic through inoculation with *Cercospora beticola* for over forty years. This epiphytotic has been used to evaluate and select for resistance to leaf spot caused by *C. beticola*. We have been pleased to participate in and lead this cooperative research project between the ARS, Colorado State University, and the BSDF.

In 2002 the project primarily involved field studies conducted at the Crops Research Lab-Fort Collins Research Farm near Wellington, CO. Randomized complete-block designs, with three replications, were used to evaluate commercial and experimental entries. Internal controls included a highly susceptible synthetic (SP351069-0) and a resistant check (FC504CMS/FC502-2//SP6322-0). Two-row plots were 12 feet long, with 22-inch row spacing and an 8 - to 10-inch within-row plant spacing. The trial was planted on May 3. Inoculations were performed on July 12 and July 18. Evaluations were made on September 5, 14, 19, and 25, with the peak of the epidemic occurring around the last date. The field was sprayed three times with Betamix Progress (June 13, 21, and July 9) and twice with Upbeet (June 13 and 21) and Stinger (June 21 and July 9) to control weeds. The field was thinned by hand and irrigated as necessary.

Figure 2. Summary the 2002 weather data for our Cercospora Leaf Spot Nursery.

The high daytime and low nighttime temperatures in the summer of 2002 and very low moisture (14 cm or 5.9" between April and October, Figure 2) contributed to a mild leaf spot epidemic, which did not become severe enough to rate until the beginning of September. Disease severity increased through September. By the final rating, means of the resistant and susceptible internal control were 3.8 and 4.5 (scale of 0-10), respectively across the nursery. In 2001 (September 17) these means were 4.97 and 6.42, respectively. Means of contributor lines in 2002 ranged from 2.7 to 5.7.

USDA-ARS 2002 Cercospora Disease Nursery, Fort Collins, CO.

Table 2. Summary data of the entire 2002 Cercospora leaf spot disease nursery. The experiment mean, the mean of the susceptible check, and the mean of the resistant check are given for each of the experiments in the nursery, for each evaluation date.

	September 14th Disease Index				September 19th Disease Index				September 25th Disease Index			
Exp.	Mean	Sus.[1]	Res.[2]	LSD	Mean	Sus.	Res.	LSD	Mean	Sus.	Res.	LSD
1A	3.6	4.3	4.0	1.06	3.9	4.3	4.0	0.90	4.2	5.0	4.3	0.85
2A[3]	3.2	4.0	3.0	1.00	3.5	4.0	3.0	1.34	3.9	4.5	3.5	0.91
3A	3.2	4.0	4.0	0.94	3.6	4.3	4.0	0.84	4.0	4.7	4.0	0.86
4A	3.1	3.3	3.0	0.96	3.5	4.0	3.7	1.07	3.8	4.3	3.7	0.73
5A	2.9	3.0	3.7	1.04	3.2	3.7	4.0	ns	3.7	4.3	4.0	0.87
6A	3.1	3.7	2.7	0.80	3.8	4.0	3.3	0.68	4.1	4.3	4.0	0.64
7A	3.0	4.0	3.3	ns	3.4	4.5	3.7	ns	3.7	5.0	3.7	0.87
8A[3]	2.6	3.0	3.0	ns	2.9	3.5	3.0	ns	3.5	4.0	3.0	0.76
Mean	3.09	3.66	3.34		3.48	4.04	3.59		3.86	4.51	3.78	

[1]Cercospora Susceptible Check - SP351069-0
[2]Cercospora Resistant Check - FC 504CMS/FC 502-2//SP6322-0
[3]There were only two replications of Experiment 2A & 8A.

Screening Biological Control Agents for *Rhizoctonia solani* Control on Sugar Beets (BSDF Project 420)

L.E. Hanson [1], L. Panella [1], A.L. Hill [1], G.M. Preston[2]
[1]USDA-ARS, Fort Collin, Colorado; [2]University of Oxford, UK

Rhizoctonia root and crown rot (caused by the fungus *Rhizoctonia solani* Kühn) is the most common and most serious fungal root disease of sugar beet in the United States. The disease is endemic in beet producing areas of the United States. *Rhizoctonia solani* also causes a damping-off in sugar beet seedlings. If the infection is light, the fungus may cause crown rot or dry rot canker on maturing roots later in the season. Thus control of this fungus in the seedling stage might offer some reduction in disease later in the season, as well as improving crop stands.

Biological control can provide an alternative to chemical pesticides which are the subject of increasing regulation and restrictions due to environmental and public health concerns. Biological control is compatible with host genetic resistance and thus can be used in an IPM program. While resistance to *R. solani* is available, it does not provide complete immunity and resistance is not well expressed in seedlings, thus the addition of other control methods is desirable.

In 2002, four *Pseudomonas fluorescens* strains (PMS382, F113, SBW25, and ΔWSP) from G. M. Preston were used. All four strains showed biological control activity against *Pythium ultimum* in Dr. Preston's work. *Trichoderma virens* strains included two strains (G-6 and G-4) from Texas cotton field soil with activity against damping-off in cotton, two UV-mutants of strain G-6, one (AB1-5) with biological control activity on cotton and one (AB1-4) without biological control activity, and five one isolates obtained from sugar beet, LH-2, SB-1, T2, T3, and T33. In addition, two *T. koningii* strains (Tk-7 and TkG-12) and one *T. atroviride* strain were used in tests. Additional strains from sugar beet are being obtained and will be included in future tests.

In *in vitro* antibiosis tests against *R. solani*, one of the *P. fluorescens* strains, PMS382, gave the greatest inhibition, but all bacterial isolates inhibited *R. solani* growth on PDA. In tests with *Trichoderma*, PMS382 inhibited the growth of all strains of *Trichoderma* tested. The three other *P. fluorescens* strains did not significantly inhibit growth of any of the *T. virens* strains, indicating that these bacterial and fungal strains may be used in combination. Growth of *T. atroviride* and *T. koningii* was inhibited by F113, but not by SBW25 or ΔWSP. None of the *Pseudomonas* strains were significantly inhibited by any of the fungal strains. When seed was soaked in a *Pseudomonas* suspension (F113 or SBW25), air dried, and treated with *T. virens* grown in wheat bran+peat moss, both *Pseudomonas* and *T. virens* could be isolated from the seed.

In antibiosis tests against *R. solani*, *T. virens* strains G-6, T2, T3, T33 and SB-1 inhibited *R. solani*, while G-4, AB1-5, LH-2 and AB1-4 showed no inhibitory activity. Strain G-6 is a "q" strain of *T. virens* that produces the antibiotic gliotoxin, which has activity against *R. solani*. Strain G-4 is a "p" stain of *T. virens* that produces the antibiotic gliovirin, which has activity against *Pythium ultimum*, but not against *R. solani*. Our results indicate that T2, T3, T33, and SB-1, which we isolated from sugar beet roots, are "q" strains. In studies in 2001, the *T. atroviride* strain and *T. koningii* strain Tk-7 had not inhibited *R. solani in vitro* while *T. koningii* strain TkG12 showed weak inhibition of *R. solani*.

In greenhouse tests for biological control activity, seed treatment with wheat bran+peat moss preparations of G-6, LH-2, and AB1-5 significantly increased seedling survival in all tests (example see table 3). Seed treatment with SB-1 and G-4 each showed significantly increased seedling survival in more than half of all tests, but survival was lower than with G-6 and results were more

variable. T2, T3, and T33 each showed activity in at least one test, but survival was lower than with G-6. No significant increase in survival was observed with AB1-4 in any tests. All of the *T. virens* strains colonized the root system well. No significant disease control was observed for the *T. atroviride* or *T. koningii* strains.

In field tests for biological control activity, seed treatment with wheat bran+peat moss preparations of SB-1 significantly increased seedling survival (Table 3). No significant increase was detected for G-6 or LH-2. Differences between activity in greenhouse and field tests are not unusual with biological control agents. For example, isolate G-6 was from acid soil and is reported to provide control in acid soils, but little or no control in alkaline soils. The soil in this field was approximately pH 7.6.

No detectable growth promotion was observed with any of the *Trichoderma* strains on sugar beet seedlings. There were no significant differences in seedling height, shoot weight, or root weight between control plants and those treated with *Trichoderma* in the absence of *R. solani*.

Table 3. Emergence and survival of sugar beet (FC403) seedlings with and without *R. solani* (AG2-2) treated with a wheat bran + peat moss preparation of *T. virens* strain G-6 or with the wheat bran + peat moss carrier alone.

Treatment	Percent survival, greenhouse[1]	Percent survival, field[2]
Carrier control	44 ab[3]	58 a
G-6	48 ab	68 a
LH-2	66 a	57 a
SB-1	46 ab	57 a
AB1-4	33 bc	59 a
R. solani (R9)	8 d	10 c
AB1-4 + *R. solani*	19 cd	9 c
LH-2 + *R. solani*	41 bc	13 c
SB-1 + *R. solani*	33 bc	22 b
G-6 + *R. solani*	30 c	12 c

[1] Average percent seedling survival from three replicates 14 days after planting in the greenhouse.
[2] Average percent seedling survival from six replicates 21 days after planting under field conditions.
[3] Percentages in the same column followed by the same letter are not significantly different by Fischer's LSD3 (α=0.05).

Variability in *Fusarium oxysporum* from sugar beets in the Central High Plains growing areas (BSDF Project 421)

L.E. Hanson, L. Panella, A.L. Hill
USDA-ARS, Fort Collin, Colorado

Fusarium yellows causes significant reduction in root yield, sucrose percentage and juice purity in affected sugar beets (Schneider & Whitney 1986). Research in our laboratory and others on variability in *Fusarium oxysporum* associated with sugar beets demonstrated that isolates that are pathogenic on sugar beet can be highly variable. A better understanding of this variability is important in the efforts to test for Fusarium yellows resistance in beets and efforts to breed for resistance.

In 2001, 62 *Fusarium* isolates were obtained from sugar beets and identified to species. In 2002, these isolates were tested for pathogenicity on sugar beet. From the 42 *F. oxysporum* isolates identified from the 2001 collection, eight were pathogenic on sugar beets in greenhouse tests. In addition to the *F. oxysporum* isolates, isolates of *F. acuminatum, F. avenaceum, F. equiseti, F. moniliforme* and *F. solani* were obtained from diseased sugar beet, all of which have been reported from growing sugar beets. One isolate each of *F. acuminatum, F. avenaceum, F. moniliforme* and *F. solani* caused moderate levels of Fusarium yellows symptoms. *F. acuminatum* previously has been reported to cause yellows-type symptoms in sugar beet (Ruppel 1991), but *F. avenaceum* and *F. solani* have been reported to cause seedling disease (Ruppel 1991) or postharvest rot (Bosch & Miroch 1992) but not typical yellows.

In 2002, 115 isolates of *Fusarium* were obtained. To date, we have identified 49 *F. oxysporum* isolates as well as isolates of *F. solani, F. avenaceum, F. acuminatum, F. equiseti, F. proliferatum,* and *F. subglutinans*. *Fusarium subglutinans* has been reported from stored sugar beet (Bosch & Miroch 1992), but not from actively growing beets. These isolates are being tested for pathogenicity in the greenhouse. In addition, three *F. oxysporum* f. sp. *spinaciae* isolates were kindly provided by Dr. L. duToit. These isolates were obtained from spinach and had been demonstrated to be pathogenic on spinach. In greenhouse tests, all three spinach isolates were pathogenic on sugar beet with a moderate level of virulence.

Isolates of *F. oxysporum* so far obtained in this study include isolates from California, Colorado, Minnesota, Montana, Nebraska, North Dakota, Oregon, Washington, and Wyoming. Pathogenic isolates are primarily from Colorado, with a few pathogenic isolates from Montana, Oregon, and Washington. DNA has been extracted from all pathogenic isolates obtained in 2000 and 2001 to be used in RAPD analysis to examine genetic variability.

To look for differences in host response in different isolates, an isolate of *F. oxysporum* from Oregon that was moderately virulent on sugar beet susceptible germplasm FC716 and an isolate from Colorado that was highly virulent on FC716 were tested on 9 beet lines with reported resistance to Fusarium yellows. On FC716, the susceptible control (Fig. 3), the highly virulent isolate (FOB 216c) caused higher disease levels than did the moderately virulent isolate (FOB 13). Similar results were observed for five of the resistant lines (example Fig 4), with overall disease levels lower on these lines than for the susceptible line. On two of the resistant lines, the two *Fusarium* isolates did not cause significantly different disease levels (example Fig 5) . On two resistant lines, isolate FOB13 was significantly more virulent than FOB216c (example Fig 6). This demonstrates variability in the interaction between different *F. oxysporum* isolates and sugar beet lines.
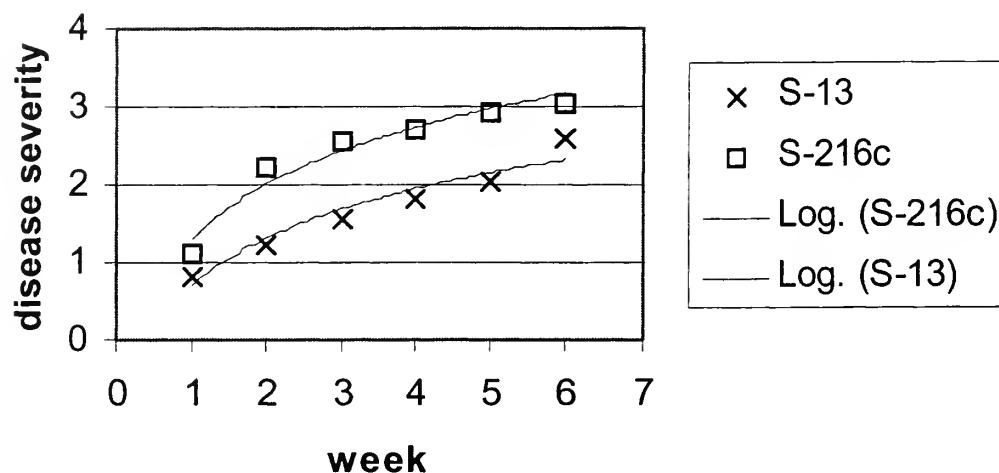
Figure 3. Disease severity ratings for two *F. oxysporum* isolates on susceptible (S) control sugar beet line. Each point is an average from 10 plants.
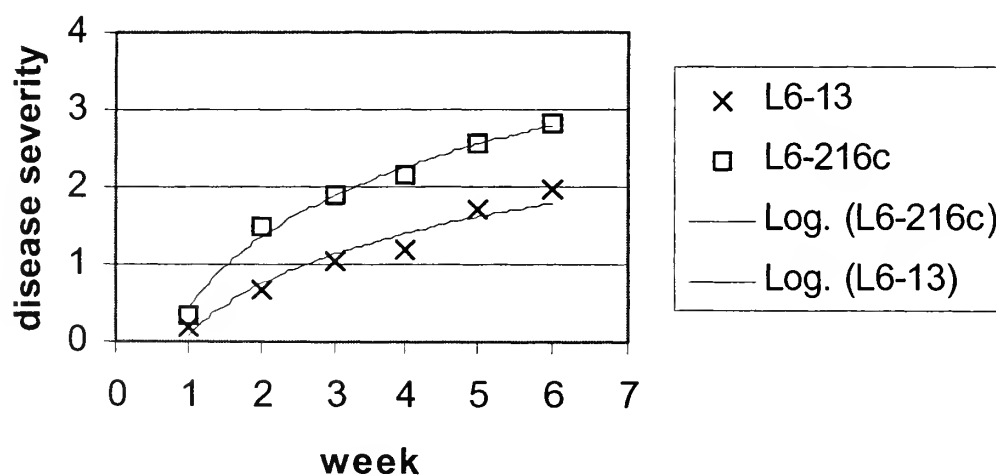
Figure 4. Disease severity ratings for two *F. oxysporum* isolates on a resistant sugar beet line. Response pattern typical for the majority of the lines tested, with FOB 216c giving a higher disease severity rating that FOB 13.
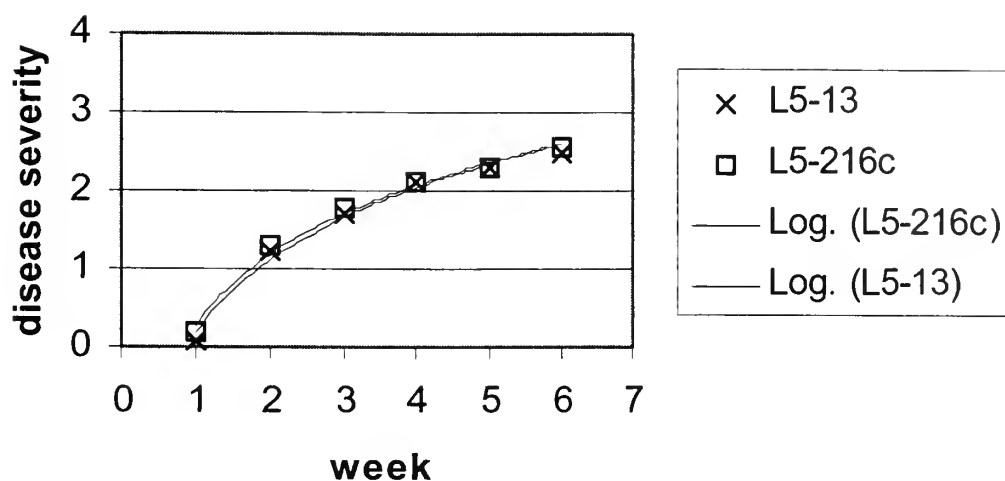
Figure 5. Disease severity ratings for two *F. oxysporum* isolates on a resistant sugar beet line. Response pattern seen with two lines, with no significant difference between the two fungal isolates.
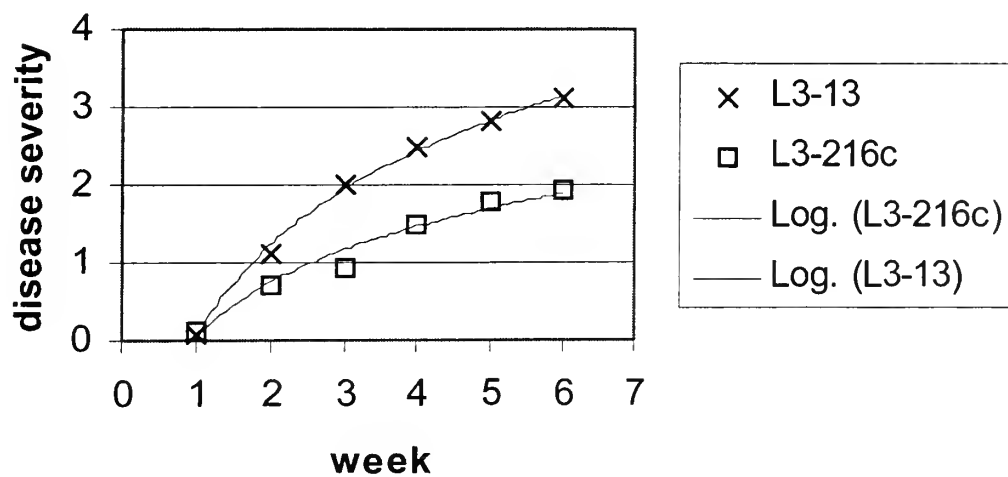
Figure 6. Disease severity ratings for two *F. oxysporum* isolates on a resistant sugar beet line. Response pattern seen with two lines, with isolate FOB 13 causing significantly higher disease ratings than FOB 216c.

References.

Bosch, U. and C.J. Miroch. 1992. Toxin production by *Fusarium* species from sugar beets and natural occurrence of zearalenon in beets and beet fibers. Applied and Environmental Microbiology. 58:3233-3239

Ruppel, E.G. 1991. Pathogenicity of *Fusarium* spp. from diseased sugar beets and variation among sugar beet isolates of *F. oxysporum*. Plant Disease. 75:486-489

Schneider, C.L. and E.D. Whitney. 1986. Fusarium Yellows. In Compendium of Beet Diseases and Insects, E.D. Whitney and J.E. Duffus, Ed. APS Press. St. Paul, Minn. Pg. 18.

Rhizoctonia Root Rot Resistance
And Development of Genetic Resistance in Sugar Beet (BSDF Project 440)

L. Panella & L. E. Hanson
USDA-ARS Fort Collins, Colorado

Rhizoctonia root rot continues to be a problem in most sugar beet-growing areas in the United States, and is a growing problem world wide. The practice of short rotations and the expansion of growing areas into infested areas compound the problem. The result is a reduction in net returns to growers as well as processing losses due to reduced sucrose and purity of rotted or partially rotted beets. Genetic resistance, coupled with judicious cultural measures, is a more economical and practical method of reducing losses caused by this fungus than is a strictly chemical control regime. There is also a strong need of combining Rhizoctonia root rot resistance with Rhizomania resistance.

This has been an ongoing and productive project, and has been the only public research project with the goal of discovering, developing, and releasing *Rhizoctonia*-resistant germplasm to industry breeders, our major external customers. Although several relatively resistant germplasms have been developed, we need to continue to combine this resistance with resistance to other diseases, and to develop a faster means of introgressing this resistance into more commercially acceptable materials.

Summary of Literature

Twenty-five years ago, Leach and Garber (1970) reviewed resistance to *Rhizoctonia* infection and concluded, "In general, while it has been possible to identify differences among cultivars or selections in susceptibility to Rhizoctonia infection, it is extremely rare that a high degree of resistance has been found or produced by selection or breeding within a susceptible host species." However, one of the most effective and environmentally safe ways to manage plant disease is with resistant germplasm (Sherf and MacNab, 1986). Soilborne pathogens like *Rhizoctonia* are often difficult to control chemically. Fumigation is expensive, providing only a temporary solution. The use of Quadris™[1] provides the first real chemical control for this disease. However, we are finding that timing of application is crucial. Additionally, spot spraying can be time consuming, and spraying a whole field because of a few patches of disease also can be expensive. The use of resistant germplasm, coupled with crop rotation and other cultural practices, can provide excellent management of diseases caused by *Rhizoctonia solani*.

In sugar beet (*Beta vulgaris* L.), Rhizoctonia root- or crown-rot is caused by *Rhizoctonia solani* (AG-2-2). Seedling damping-off in sugar beet primarily is caused by *R. solani* AG-4. Root-rot is endemic in sugar beet growing areas across the United States. John Gaskill began breeding for resistance in the late 1950s and released his first resistant germplasm in 1966 (Gaskill, 1968). Current *Rhizoctonia*-resistant germplasm has a level of resistance in which there is no yield loss under disease pressure in the field (Ruppel and Hecker, 1994). It was realized early that natural field epiphytotics did not produce the necessary consistent, uniform disease pressure for recurrent mass selection (Pierson and Gaskill, 1961). Artificially induced epiphytotics (Ruppel et al., 1979; Schneider et al., 1982) were developed to provide uniform, heavy disease pressure to be able to

---

[1]Mention of a trademark or manufacturer by the USDA does not imply its approval to the exclusion of other products or manufacturers.

perform mass selection or recurrent field selection (Hecker and Ruppel, 1977).

The resistance to *R. solani* in sugar beet developed by John Gaskill is polygenic, involving at least two loci, two or three alleles, and modifying genes in some populations (Hecker and Ruppel, 1975). Broad-sense heritability has been estimated at about 0.65, and there are nonadditive components of the variance (Hecker and Ruppel, 1975). In a study by Hecker and Ruppel (1976) dominance effects were present in diploid, triploid, and tetraploid resistant hybrids. Relatively high heritability has aided in the development of increasing host plant resistance to Rhizoctonia root- and crown-rot, and we have released over 15 germplasm lines in the last 10 years. *Rhizoctonia* resistance has been released in O-type maintainer, CMS female, and multigerm-pollinator germplasm and remains a very important means of reducing crop damage by this disease (Herr, 1996). Genetic resistance to Rhizoctonia root rot has been an ongoing development from this project at Fort Collins. Several resistant germplasms have been released in the last five year to use as parents of hybrid cultivars or to provided source populations from which *Rhizoctonia*-resistant parents were selected or which were crossed to provided resistant parents (Panella and Ruppel, 1996; Panella and Ruppel, 1997; Panella, 1999; Panella, 2001).

Epidemiological and control studies have been reported regularly from this project (Ruppel et al., 1988). Pathogen survival in varied crop debris and soil and the interaction of pesticides with *Rhizoctonia* have been reported on the literature (Ruppel, 1985; Ruppel 1991; Ruppel and Hecker, 1982; Ruppel et al., 1982). In a 3-year study, positive significant or highly significant correlations between disease severity indices and percent decreases in yield and purity parameters indicated that there were no hidden losses to Rhizoctonia root rot in our resistant germplasms (Ruppel and Hecker, 1994).

Recently, researchers attempting to determine the anastomosis group (AG) of *Rhizoctonia solani* isolates have used several new biotechnological techniques (including RFLP, RAPD, and isozyme analyses), with some notable successes in distinguishing among, and even within, some of these groups. Recently there was a report of a definitive assay to distinguish those isolates in AG-2-2 or AG-4 that cause sugar beet root rot and damping-off, respectively, from nonpathogenic isolates obtained from soil (Lubeck and Poulsen, 2001).

References

Gaskill, J. O. 1968. Breeding for Rhizoctonia resistance in sugarbeet. J. Am. Soc. Sugar Beet Technol. 15:105-119.

Hecker, R. J. and E. G. Ruppel. 1975. Inheritance of resistance to Rhizoctonia root-rot in sugarbeet. Crop Sci. 15:487-490.

Hecker, R. J. and E. G. Ruppel. 1976. Polyploid and maternal effects on Rhizoctonia root rot resistance in sugarbeet. Euphytica 25:419-423.

Hecker, R. J. and E. G. Ruppel. 1977. Rhizoctonia root-rot resistance in sugarbeet: breeding and related research. J. Am. Soc. Sugar Beet Technol. 19:246-256.

Herr, L. J. 1996. Sugar beet diseases incited by *Rhizoctonia* spp. Chap. V.10. In: *Rhizoctonia* Species: Taxonomy, Molecular biology, Ecology, Pathology and Disease Control. (Eds: Sneh, Baruch; Jabaji-Hare, Suha; Neate, Stephen; Dijst, Gerda) Kluwer Academic Publishers, Dordrecht, 341-350.

Leach, L. D., and R. H. Garber. 1970. Control of Rhizoctonia. In: *Rhizoctonia Solani:* Biology and Pathology. (Ed: Parmeter, Jr, John R. J) University of California Press, Berkeley, 189-199.

Lubeck, M. and H. Poulsen. 2001. UP-PCR cross blot hybridization as a tool for identification of anastomosis groups in the *Rhizoctonia solani* complex. FEMS Microbiol. Lett. 201(1):83-89.

Panella, L. and E.G. Ruppel. Registration of FC725, FC726, AND FC728 sugarbeet germplasms resistant to Rhizoctonia root rot and moderately resistant to Cercospora leaf spot. Crop Sci. 36(3):819-820. 1996.

Panella, L. and E.G. Ruppel. Registration of sugarbeet germplasms FC721 and FC721CMS resistant to Rhizoctonia root rot and moderately resistant to the beet curly top virus. Crop Sci. 37(5):1675-1676. 1997.

Panella, L. Registration of FC709-2 AND FC727 sugarbeet germplasms resistant to Rhizoctonia root rot and Cercospora leaf spot. Crop Sci. 39(1):298-299. 1999.

Panella, L. Registration of FC712 (4X) tetraploid, multigerm sugarbeet germplasm. Crop Sci. in press. 2001

Pierson, V. G. and J. O. Gaskill. 1961. Artificial exposure of sugar beets to *Rhizoctonia solani*. J. Am. Soc. Sugar Beet Technol. 11:574-590.

Ruppel, E. G. 1985. Susceptibility of rotation crops to a root rot isolate of *Rhizoctonia solani* from sugar beet and survival of the pathogen in crop residues. Plant Dis. 69, 871-873.

Ruppel, E. G. 1991. Survival of *Rhizoctonia solani* in fallow field soil and buried sugarbeet roots at three depths. J. Sugar Beet Res. 28(3 & 4), 141-153.

Ruppel, E. G., R. L. Gilbertson and E. E. Schweizer. 1988. Population densities of selected soil-borne fungi and disease incidence in a crop rotation under varied weed-management systems. Agr. Ecosys. Envir. 21, 163-169.

Ruppel, E. G. and R. J. Hecker. 1982. Increased severity of *Rhizoctonia* root rot in sugar beet treated with systemic insecticides. Crop Protection 1(1), 75-81.

Ruppel, E. G. and R. J. Hecker. 1994. Rhizoctonia root rot on sugarbeet cultivars having varied degrees of resistance. J. Sugar Beet Res. 31:135-142.

Ruppel, E. G., R. J. Hecker and E. E. Schweizer. 1982. *Rhizoctonia* root rot of sugarbeet unaffected by herbicides. J. Am. Soc. Sugar Beet Technol. 21(3), 203-209.

Ruppel, E.G., C. L. Schneider, R. J. Hecker, and G. J. Hogaboam. 1979. Creating epiphytotics of *Rhizoctonia* root rot and evaluating for resistance to *Rhizoctonia solani* in sugarbeet field plots. Plant Dis. Rep. 63:518-522.

Schneider, C. L., E. G. Ruppel, R. J. Hecker, and G. J. Hogaboam. 1982. Effect of soil deposition in crowns on development of *Rhizoctonia* root rot in sugar beet. Plant Dis. 66:408-410.

Sherf, A. F. and A. A. MacNab. 1986. *Vegetable Diseases and Their Control*. Wiley, New York. 728 p.

OBJECTIVES:

1.	Plant mother roots and selections for seed production and ultimate release to breeders for use as populations from which to develop *Rhizoctonia-* and rhizomania-resistant parents in hybrid cultivars.

2.	Combine resistance to *Rhizoctonia* with that of other important pathogens (esp. Rhizomania) in germplasm with good agronomic performance.

3.	Develop *Rhizoctonia*-resistant populations from different genetic sources of resistance.

4.	A longer range goal (in collaboration with Mitch McGrath, USDA-ARS East Lansing) is the development of molecular markers linked to the genes in sugar beet controlling resistance to *R. solani.*

Materials and Methods:

Field isolation plots and greenhouse isolation chambers in Fort Collins will be used for seed production from mother roots and selections of advanced germplasms having been field selected for resistance to Rhizoctonia root rot. The Fort Collins environment has proven extremely valuable in these efforts. The arid climate, low organic matter content of the soils, and hot, dry winds are not conducive to the development of soilborne or foliar diseases. Therefore, when artificial epiphytotics, developed by Gaskill and Ruppel, are created to test sugarbeet for resistance to Rhizoctonia root rot there is little confounding of the results by the presence of other diseases.

Selected resistant populations resulting from crosses with material containing the single *Rz* gene source of resistance to Rhizomania will be sent to Salinas for field selection for Rhizomania resistance. Alternating cycles of selection in Salinas and Fort Collins (and Kimberley, ID for curly top resistance) will be used to increase disease resistance. Seed increases will be made and the germplasms will be released as adequate seed becomes available.

Molecular genetic studies will concentrate on looking at the response of the sugar beet to attack by *Rhizoctonia solani.* A longer range goal (in collaboration with Mitch McGrath, USDA-ARS East Lansing) is the development of molecular markers linked to the genes controlling resistance to *R. solani.* Populations are being developed at East Lansing for this purpose and molecular markers (SSRs & AFLPs) at both Fort Collins and East Lansing.

2002 Field Research on Rhizoctonia Root Rot of Sugar Beet.

Annually, for over thirty years, the sugar beet breeding program in Fort Collins has included the production of an artificial epiphytotic through inoculation with *Rhizoctonia solani* to evaluate and select for resistance to root rot caused by this pathogen. We have been pleased to participate and lead this cooperative research project between the ARS, Colorado State University, and the BSDF.

In 2002 the project involved field studies conducted at the Crops Research Lab-Fort Collins Research Farm near Wellington, CO. Randomized, complete-block designs with five replicates were used to evaluate ARS breeding germplasm and Plant Introduction accessions. *Rhizoctonia*-resistant line FC703, highly resistant FC705-1, and highly susceptible FC901/C817 were included as internal controls.

One-row plots, planted May 23rd, were 14 feet long with 22 inches between rows and 8-10

inches within-row spacing. Inoculation with dry, ground, barley-grain inoculum of *Rhizoctonia solani* AG2-2 isolate R-9 was performed on July 17th; immediately after inoculation, a cultivation was performed so as to throw soil into the beet crowns. The field was sprayed three times with Betamix Progress (June 26, July 10 and July 22) and twice with Upbeet (June 26 and July 10) and Stinger (July 10 and 22) to control weeds. The field was thinned by hand and irrigated as necessary. Beets were harvested September 4 through 7. Each root was rated for rot on a scale of 0 to 7 (dead) as previously described. ANOVAs were performed on disease indices (DIs), percent healthy roots (classes 0 and 1 combined), and percentage of roots in classes 0 thru 3. Percentages were transformed to arcsin-square roots to normalize the data for analyses. LSDs are provided for comparing entries with those of our internal checks.

The high daytime temperatures in the summer of 2002 (Figure 1), combined with a moderate inoculum load, contributed to a severe root rot epidemic. Severe disease developed by early September. Mean DIs across all tests for highly resistant FC705-1, resistant FC703, and highly susceptible FC901/C817 controls were 1.7, 2.2, and 4.4 respectively. Percentages of healthy roots were 46.5, 34.2, and 10.4% for these controls. Percentages of roots in disease classes zero thru three were 85.9, 74.1, and 29.8, respectively. The highest and lowest DIs for the evaluated lines were 6.9 and 1.3, respectively.

Table 4.   Allotment of Fort Collins "FC" numbers (3-digit numbers)

"FC" numbers are "convenience" numbers for "seed releases" or purposes where a permanent line designation is needed — i.e. a number that does not change from generation to generation where little or no selection pressure is applied. Initially, an "FC" no. was written thus "FC 501" [now FC727], "FC 502 CMS" [now FC715CMS], etc. Sublines (from selfing) were designated thus, "FC 502/2" [now FC709-2], "FC502/3" [now FC502-3], etc. The same applies when the line is substantially changed by selection without selfing.

Below 500	Originally LeRoy Powers - now parental lines and special genetic stocks.
500's	Leaf Spot Resistant (LSR), Type-O lines & male steriles [CMS]
600's	LSR-Curly Top Resistant (CTR), type-O lines & male steriles [CMS]
700's	Rhizoctonia Resistant
800's	LSR-CTR-Rhizoctonia resistant
900's	Pollinators, LSR-CTR type

This year, I also completed a third year of evaluation of most of the *Rhizoctonia*-resistant lines released from the USDA-ARS breeding project at Fort Collins (Table 7). This is a test from 2001 under the same conditions as the other contributor lines in this year's test.

***Rhizoctonia*-Resistant Populations Under Development**

Rhizoctonia root rot continues to be a problem in most sugar beet-growing areas in the United States, and is a growing problem world wide. The practice of short rotations and the expansion of growing areas into infested areas compound the problem. The result is a reduction in net returns to growers as well as processing losses due to reduced sucrose and purity of rotted or partially rotted beets. Genetic resistance, coupled with judicious cultural measures, is a more economical and practical method of reducing losses caused by this fungus than is a strictly chemical control regime. There is also a strong need of combining Rhizoctonia root rot resistance with Rhizomania resistance.

This has been an ongoing and productive project, and has been the only research project with the goal of discovering, developing, and releasing Rhizoctonia-resistant germplasm to industry breeders, our major external customers. Although several relatively resistant germplasms have been developed, we need to continue to combine this resistance with resistance to other diseases, uncover new sources of resistance, and work to more quickly introgress this resistance into germplasm with higher sucrose yield potential.

Current Research 2002 – Germplasm under development:

With the release of FC720, FC722, FC722CMS, FC723, FC723CMS, FC724 and FC710(4X) in 2003, most of the germplasm remaining from the program of Dr. Richard Hecker will have been evaluated, improved and released or shelved. Current Rhizoctonia-resistant germplasm under development consists of populations being jointly developed with Dr. Robert Lewellen in Salinas (numbers one and two below). These populations are being improved to combine *Rhizoctonia* and Rhizomania resistant in a genetic background with good sucrose yield potential. Additionally, a population under development with Larry Campbell has the potential of providing root maggot resistance along with *Rhizoctonia* resistance.

1. *Rhizoctonia*-resistant monogerm polycross base population developed by a cross between FC708 and two Salinas germplasms, 2890 and 2859.
    A. 2890 (sp) 0790 *mm aa* x 1890 (Salinas); is seed from *aa* plants open pollinated by A- plants. 0790 = population-790 cycle 5 synthetic by S_1 progeny, M.S. mm, O-type, good combining ability, adapted to California, S^f,. 1890 = BC population to population 790 to get Rz equivalent, remains variable for M-:mm, Rz-:rzrz, etc.
    A. 2859 m (sp) = 1859, 1859R aa x A- (Salinas); Released in 1992 as C859. S^f, similar to 2890, but should have higher curly top resistance (CTR). Segregates and variable for M-:mm, Rz-:rzrz, A-:aa, predominant background is lines like C563, which is widely used in western USA as source of CTR, mm, O-type.

2. Rhizoctonia root rot resistance multigerm base population developed by a cross between FC709-2 and a Salinas germplasms, 2915.
    A. 2915 (sp) RZM 1915-#m 1913-# aa x A (Salinas); Seed harvested from aa (ms) plants open-pollinated by A- (fertile) plants. This population will segregate for A-:aa, Rz-:rzrz, $s^s s^s$:s^f-, ($>\frac{1}{2}$ s^f), R-:rr, It will be multigerm, have moderate to good tolerance to virus yellows, curly top, bolting, *Erwinia*; variable for reaction to powdery mildew, production traits. Individual plants will be either As or aa.

Background of population is mostly from OP, MM lines such as C46, C37.

Progress in 2002

1. Final testing and seed increase of monogerm O-type lines with and without and CMS equivalents, selected in the 1996 Rhizoctonia nursery were completed and those lines (listed above) will be released. (Table 5, 6 & 7 – Experiments 7R, 2001; 7A, 2001; & 7R 2002).

2. This population (FC708/2890&2859) has been divided into three breeding lines. One has been selected for resistance to curly top (selfed progeny tested in Kimberley, ID) and *Rhizoctonia* (individual plants selected in the Fort Collins nursery), and is currently being increased for testing and re-selection. Another population has been selected for resistance only to *Rhizoctonia* (individual plants selected in the Fort Collins nursery), and is currently being increased for testing and re-selection. The third line was selected for Rhizomania resistance and agronomic performance (individual plants selected in the Salinas nursery) and is currently being re-selected and recombined for further testing (Table 8 - Experiment 4R, 2001).

3. This population (FC709-2/2915) has been divided into four breeding lines selected in Fort Collins, CO, and Kimberley, ID. Two have been selected for resistance to *Rhizoctonia* (individual plant selections and half-sib families selections), one was selected for resistance to *Rhizoctonia* and curly top virus (half-sib families selections), and one was selected for resistance to curly top (half-sib families selections). Three of the populations were planted in Dr. R. Lewellen's Rhizomania/steckling nursery for selection for resistance to rhizomania (*Rz* gene source) and for agronomic performance. Selected roots will be increased for further sucrose and rhizomania testing, selection, and release.

4. Seed, increase from *Rhizoctonia*-resistant selected roots of FC907 ((FC701 x FC607)BC$_4$), was tested in the Rhizoctonia and Cercospora nurseries. Selections made in a (FC709-2 x FC907)F$_2$ population in the *Rhizoctonia* nursery were increased in the greenhouse and tested in the Rhizoctonia and curly top nurseries. This population will be re-selected in the Rhizoctonia nursery and then tested in the Rhizoctonia, Cercospora, and curly top nurseries and evaluated for release (Table 7 - Experiment 7R, 2002; Table 8 - 4R 2001; Table 10 - Experiment 7A, 2002; Table 11).

5. A number of accessions from the NPGS *Beta* collection that have shown *Rhizoctonia*-resistance in the screening program have been identified. They will be re-screened in 2003. Special attention will be paid to those accessions screened in 1987 and 1992 because the tests in those years appears to have been unreliable. Crosses will be made between any that appear to have resistance using a female parent with high sucrose yield potential. The goal is to develop *Rhizoctonia*-resistant populations from potentially different sources of resistance. These will be available from which to choose resistant hybrid parents or germplasm to cross into programs developing *Rhizoctonia*-resistant hybrid parents (See table 9).

Table 5. Experiment 7R, 2001. Rhizoctonia Evaluation of USDA-ARS Fort Collins Released Germplasm.

Seed Source	Release	DI[1]	% Hlthy[2]	% 0 - 3[3]	Z%[4] Hlthy	Z% 0 - 3[4]
	(<3.84) LSD[5]	0.76			16.79	17.96
Susceptible Check[6]	941025	4.6	3	23	6.1	24.9
Experiment Mean		2.3	33	83	32.1	72.0
751080H	FC703[8]	2.6	21	76	21.6	63.6
831083	FC705/1[7]	1.6	55	98	47.8	86.0
961015	FC720-1	1.7	47	99	43.3	87.4
961010HO	FC722-1	2.4	17	85	19.0	72.1
961010HO1	FC722CMS	2.4	13	95	16.3	84.0
951016HO	FC723	2.1	38	91	37.1	79.3
951016HO1	FC723CMS	2.1	27	93	29.9	74.7
961014	FC724	1.7	41	99	38.8	87.2
971017	FC710(4X)	2.5	15	87	15.0	79.0

[1]Disease Index is based on a scale of 0 (=healthy) to 7 (= plant dead).
[2]Percent of healthy roots (disease classes 0 and 1 combined).
[3]Percent of diseased roots likely to be taken for processing (disease classes 0 through 3 combined).
[4]Percentages were transformed to arcsin-square roots to normalize the data for analyzes.
[5]P=0.05
[6]FC901/C817
[7]FC705/1 Highly resistant check
[8]FC703 Resistant check

Table 6. Experiment 7A, 2001. Leaf Spot Evaluation of USDA-ARS Fort Collins experimental breeding lines.

Entry	Identification	Disease Index[1]			
		Sept. 3rd	Sept. 10th	Sept. 17th	Sept. 24th
	LSD$_{0.05}$	1.05	1.24	1.15	1.21
	CV	23.6	22.3	15.0	19.4
LSS[2] (931002)		4.3	5.3	6.0	5.7
LSR[3] (821051H2)		2.7	2.3	4.8	4.0
Trial Mean		2.7	3.4	4.7	3.8
(FC907 X FC709-2)-sel single family	20001008	1.7	2.3	2.7	2.3
FC715	911026HO	2.3	2.2	3.3	2.7
FC709-2	20001016HO	1.8	2.2	3.3	2.5
FC723 – EL44/FC708 mm	951016HO	2.7	2.7	3.7	2.7
FC723 CMS – EL44/FC708 CMS	951016HO1	3.0	2.7	4.0	3.2
(FC907 X FC709-2)-sel multiple families	20001009	2.3	3.0	4.2	4.0
FC907-1 – FC607/FC701 BC4	971020	2.2	3.0	4.5	3.3
FC712/MonoHy A4 - CMS equivalent	20011003HO1	2.8	4.2	4.8	4.2
FC722 CMS – C718/FC708 CMS	961010HO1	2.3	3.5	5.0	4.0
FC607	97A050	2.3	3.2	5.3	4.3
Rhx=zcRmm (991001) (2859&2890) xFC708	20011016	3.2	4.0	5.5	4.7
(2859 & 2890 X FC607 & FC604) CTR	981011H	3.3	4.0	5.5	5.0
FC722-1 – C718/FC708	961010HO	2.8	5.0	6.0	5.0
FC712/MonoHy A4	20011003HO	2.7	3.5	6.0	4.0

[1]Disease Index is based on a scale of 0 (=healthy) to 10 (=dead).
[2]The Leafspot Susceptible Check is SP351069-0.
[3]The Leafspot Resistant Check is ((FC504CMS x FC502/2) x SP6322-0).

Table 7. Experiment 7R, 2002. Rhizoctonia Evaluation of USDA-ARS Fort Collins Released Germplasm.

Entry	Seed Source	Release/Description	DI[1]	% Hlthy[2]	% 0 - 3[3]	Z%[4] Hlthy	Z% 0 - 3[4]
		LSD[5] (<4.19 significantly better than susceptible check)	0.90			19.75	19.27
		Susceptible Check[6]	5.1	6	21	9.1	23.7
		Experiment Mean	3.0	26	67	26.2	57.0
		CV	24.7				
941	931024	FC701	4.2	7	34	11.4	32.6
942	761068H	FC701-4	2.6	30	74	32.1	59.4
943	721056	FC701-5	2.6	35	74	29.9	62.4
944	801059H	FC701-6	2.1	43	86	38.0	71.1
945	681009-0	FC702	4.6	0	43	0.0	36.1
946	991016	FC702/2	3.7	4	46	7.1	42.6
947	20011009	FC702-4(4X)	2.8	33	67	31.8	55.3
948	811055H	FC702-6	2.1	45	86	39.1	72.8
949	**751080H**	**FC703[8]**	**2.9**	**23**	**69**	**27.5**	**59.6**
950	19991017	FC703	2.9	21	65	26.9	54.4
951	931021	FC704	6.2	0	0	0.0	0.0
953	781066H	FC705	2.3	34	83	34.4	69.0
954	20001019	FC705	2.0	39	92	38.2	75.3
955	**831083.0**	**FC705/1[7]**	**1.7**	**58**	**94**	**50.1**	**81.4**
956	20001020.0	FC706	2.9	25	64	26.7	56.0
957	20001021.0	FC707	2.3	40	78	39.2	62.2
958	83108SHO	FC708	2.5	27	77	27.7	64.5
960	20001016HO	FC709-2	1.7	51	99	45.7	86.9
961	891033	FC710	2.2	39	84	38.1	68.8
962	971017	FC710(4X)	2.0	35	97	32.9	85.1
963	20001022	FC710(4X)	2.4	31	80	29.9	66.9
964	821087	FC711	3.0	5	66	8.1	57.4
965	881032H	FC712	2.1	50	81	45.2	65.0
966	971018	FC712(4X)	1.7	57	93	49.1	80.5
967	911026HO	FC715	2.9	33	68	29.5	62.3
968	971019	FC716	2.5	28	76	28.7	63.7
969	981025	FC717	3.5	9	50	11.4	45.5
970	911032	FC718	2.5	27	75	28.2	60.8
971	911037	FC719	2.7	27	71	27.7	58.2

Table 7. Experiment 7R, 2002. Rhizoctonia Evaluation of USDA-ARS Fort Collins Released Germplasm.

Entry	Seed Source	Release/Description	DI[1]	% Hlthy[2]	% 0 - 3[3]	Z%[4] Hlthy	Z% 0 - 3[4]
		(<4.19 significantly better than susceptible check) LSD[5]	0.90			19.75	19.27
		Susceptible Check[6]	5.1	6	21	9.1	23.7
		Experiment Mean	3.0	26	67	26.2	57.0
		CV	24.7				
972	961015	FC720– C718/(C718/FC708)	2.4	30	81	30.1	67.1
973	931005HO	FC721	2.9	31	63	30.4	55.4
974	931005HO1	FC721CMS	3.4	11	51	16.8	45.9
975	961010HO	FC722 – C718/FC708	3.6	10	56	9.0	51.0
976	961010HO1	FC722CMS – C718/FC708CMS	3.8	9	37	10.9	33.8
977	951016HO	FC723 – EL44/FC708 mm	2.6	27	75	29.9	63.9
978	951016HO1	FC723CMS – EL44/FC708 CMS	3.1	21	62	21.8	52.0
979	961014	FC724 – FC702/LSR-CTR	2.5	30	80	29.4	65.4
980	921008	FC725	2.1	42	87	39.9	71.0
981	931010	FC726	2.6	28	74	28.0	60.2
982	951017	FC727	2.6	23	80	28.3	64.2
983	921025	FC728	2.3	25	86	27.3	70.5
984	921019	FC729 – FC712/A4, 3 cycles Rhizoc, MM	2.1	50	85	41.9	71.9
985	991015	FC801	3.0	18	61	24.5	51.9
986	971020	FC907-1 – FC607/FC701 BC4 - 1 cycle of RhzcR sel	4.9	0	18	0.0	22.4
987	20011007	F3 LSR MM x RhzcR/LSR sel RhzcR - hs 10A-1775	2.6	24	73	25.8	61.9
988	20011013H	F4 LSR MM x RhzcR/LSR selRhzcR - sel hs 10A	4.1	10	39	13.8	38.1
989	20021002	RhzcR/mR - (FC907 x FC709-2) x 9931	5.4	5	17	8.3	24.2
990	20011003HO	FC712/Mono-Hy A4	2.7	30	67	27.2	56.1
991	20011003HO1	FC712/MonoHy A4 CMS	2.6	29	85	29.3	72.3

[1]Disease Index is based on a scale of 0 (=healthy) to 7 (= plant dead).
[2]Percent of healthy roots (disease classes 0 and 1 combined).
[3]Percent of diseased roots likely to be taken for processing (disease classes 0 through 3 combined).
[4]Percentages were transformed to arcsin-square roots to normalize the data for analyzes.
[5]P=0.05; There were 6 missing plots, however LSD was estimated as if all plots were present.
[6]FC901/C817 - susceptible check
[7]FC705/1 - highly resistant check
[8]FC703 - resistant check

Table 8. Experiment 4R, 2001. Rhizoctonia Resistance Evaluation of Fort Collins Experimental lines.

Entry	Description	DI[1]	% Hlthy[2]	% 0 - 3[3]	Z%[4] Hlthy	Z% 0 - 3[4]
	LSD[5]	0.66			14.58	12.60
821	**Susceptible Check[6]**	**4.2**	**13**	**32**	**18.6**	**33.8**
822	**Highly Resistant Check[7]**	**1.6**	**53**	**100**	**47.1**	**90.0**
823	**Resistant Check[8]**	**1.8**	**44**	**97**	**41.2**	**85.6**
	Experiment Mean	**3.5**	**22**	**57**	**22.9**	**51.7**
806	921024 FC709-2	1.6	57	99	49.6	87.2
807	961015 FC720-1	1.7	48	100	43.7	90.0
808	951016HO FC723	2.1	38	95	37.8	82.1
809	951016HO1 FC723CMS	1.7	55	100	48.1	90.0
810	961010HO FC722-1	2.0	32	97	34.2	85.1
811	961010HO1 FC722CMS	2.3	23	97	22.7	85.6
812	961014 FC724	1.7	52	100	45.8	90.0
813	991011 FC709-2	1.8	60	90	51.3	75.9
814	2000102 (FC907 x FC709-2)F2 - RhzcR sel - RM - RM	3.7	10	60	11.5	51.8
815	20001008 (FC907 x FC709-2)F2-RhzcR sel-hs -blk 10A-1775	2.7	13	88	16.6	74.1
816	20001009 (FC907 x FC709-2)F2-RhzcR sel-hs (10A)blk	3.8	13	57	16.4	49.4
817	20011003HO FC712/MonoHyA4	2.4	31	84	30.8	67.3
818	20011003HO1 FC712/MonoHyA4 CMS	2.3	36	83	36.4	66.3
819	20011013H (FC907 x FC709-2)F2-RhzcR sel-hs (10A)blk - blk	3.7	11	55	17.0	47.7
820	20011016 ((2890aa x FC708) + (2859aa x FC708))	3.4	18	53	23.8	46.8

[1]Disease Index is based on a scale of 0 (=healthy) to 7 (= plant dead).
[2]Percent of healthy roots (disease classes 0 and 1 combined).
[3]Percent of diseased roots likely to be taken for processing (disease classes 0 through 3 combined).
[4]Percentages were transformed to arcsin-square roots to normalize the data for analyzes.
[5]P=0.05
[6]FC901/C817
[7]FC705/1
[8]FC703

Table 9. Results of a Query of the GRIN database for sugarbeet accessions with a Rhizoctonia score less than or equal to 3.

NPGS ID	Accession Name	Other names	Year(s) Evaluated	Score
PI 285590	Epipski HOSER		1987	3
PI 285593	Crassa Udycki Zolty Walcowaty		1987	3
PI 285594	Crassa Walcowaty Zolty Granum		1987	3
PI 285595	Crassa Walcowaty Zolty Pzhr		1987	3
PI 293419	Podzimniaja 0474		1987	3
PI 293420	Bordo 237		1987	3
PI 357357	Okrugla		1987	3
PI 357360	Ohridska Zolta		1987	3
PI 357361	Gostivarska Zelena		1987	3
PI 546390	WB 69	IDBBNR 5591	1990	3
PI 546510	WB 771	IDBBNR 9677	1992	3
PI 546524	WB 790	IDBBNR 9691	1992	3
PI 546527	WB 793	IDBBNR 9694	1992	3
PI 546530	WB 796	IDBBNR 9697	1992	3
PI 546531	WB 797	IDBBNR 9698	1992	3
PI 546532	WB 798	IDBBNR 9699	1992	3
PI 546533	WB 799	IDBBNR 9700	1992	3
PI 546537	WB 787	IDBBNR 9704	1992	3
PI 546538	WB 788	IDBBNR 9705	1992	3
PI 546539	WB 789	IDBBNR 9706	1992	3
PI 552532	F1012	IDBBNR 9707	1992	3
PI 558505	FC 506	IDBBNR 9711	1992	3
PI 558513	FC 401	IDBBNR 9714	1992	3
PI 558515	FC 403	IDBBNR 9716	1992	3
PI 531260	Bordo		1996	3
PI 535826	Gigant Poly		1996	3
PI 535845	Annomono		1996	3
PI 285592	Crassa Strzelecki I Har		1987 & 1998	3 & 8

Lines released for Rhizoctonia Resistance contained within the database.

PI 607379	FC712(4X)	NSL 362030	1999	3
PI 590766	FC712	IDBBNR 4591	1999	3
PI 518643	FC709	IDBBNR 9603	1999	3
PI 590754	FC705/1	IDBBNR 4571	1995 & 1999	1 & 3
PI 591336	FC 728	921025	1999	3
PI 574630	FC 719	IDBBNR 9769	1999	3
PI 599668	FC 709-2	NSL 362030	1999	2

Cercospora Leaf Spot Research And Breeding
For Cercospora And Curly Top Resistance (BSDF Project 441)

L. Panella & L. E. Hanson
USDA-ARS Fort Collins, Colorado

This element of the breeding program at Fort Collins is devoted to the development of germplasm with resistance to more than one sugar beet disease and improved agronomic characteristics. It is built on germplasm developed at Fort Collins over the last fifty years for combined resistance to Cercospora leaf spot and the curly top virus. This is an integrated breeding program with greenhouse and laboratory studies, and a field program based on testing in an artificial epiphytotic created in the unique Fort Collins environment. It involves close collaboration with the other USDA-ARS sugar beet programs in the U.S. and sugar beet seed industry customers. The major goals of this program are: 1) the development of sugar beet germplasm with resistance to more than one disease and excellent agronomic characteristics; 2) the improvement of breeding techniques, traditional and molecular, to develop this germplasm; and 3) an increased understanding of the sugar beet/pathogen interactions to improve management practices of these diseases in sugar beet production areas. Genetic information developed during this research will be used to execute additional cycles of pathogen inoculation, plant selection, and recombination among germplasms that we have in our leaf spot improvement program. Results of these tests will be the basis of decisions about specific germplasm, i.e., retain, discard, recombine, release, etc. Germplasms likely to be useful for variety improvement will be identified and released for use by other sugar beet breeders.

Increased resistance to *Cercospora* continues to be an extremely important goal. If the level of resistance available in most *Cercospora*-resistant experimental lines were present in commercial hybrids (along with good sugar and seed yield), the need for fungicides would be greatly reduced. That continued improvement in genetic resistance to this serious pathogen is still needed is evident by the occurrence of *Cercospora* strains that are resistant or increasingly tolerant to our most potent fungicides. Additionally, some of these fungicides may be removed from the market because of their perceived or real threat to the environment. In many areas where Cercospora leaf spot is a problem, the curly top virus also causes significant losses. In addition, there are some growing areas in which combined resistance to Cercospora leaf spot, Rhizomania, curly top, Rhizoctonia root rot, and other diseases is desirable. Germplasm is needed with combined resistance to these diseases, along with good combining ability for yield components.

2002 Field Research on Cercospora Leaf Spot of Sugar Beet

The breeding program in Fort Collins has created an annual artificial epiphytotic through inoculation with *Cercospora beticola* for over forty years. This epiphytotic has been used to evaluate and select for resistance to leaf spot caused by *C. beticola*. We have been pleased to participate in and lead this cooperative research project between the ARS, Colorado State University, and the BSDF.

In 2002 the project primarily involved field studies conducted at the Crops Research Lab-Fort Collins Research Farm near Wellington, CO. Randomized complete-block designs, with three replications, were used to evaluate commercial and experimental entries. Internal controls included a highly susceptible synthetic (SP351069-0) and a resistant check (FC504CMS/FC502-2//SP6322-0). Two-row plots were 12 feet long, with 22-inch row spacing and an 8 - to 10-inch within-row plant

spacing. The trial was planted on May 3. Inoculations were performed on July 12 and July 18. Evaluations were made on September 5, 14, 19, and 25, with the peak of the epidemic occurring around the last date. The field was sprayed three times with Betamix Progress (June 13, 21, and July 9) and twice with Upbeet (June 13 and 21) and Stinger (June 21 and July 9) to control weeds. The field was thinned by hand and irrigated as necessary.

The high daytime and low nighttime temperatures in the summer of 2002 and very low moisture (14 cm or 5.9" between April and October, Figure 2) contributed to a mild leaf spot epidemic, which did not become severe enough to rate until the beginning of September. Disease severity increased through September. By the final rating, means of the resistant and susceptible internal control were 3.8 and 4.5 (scale of 0-10), respectively across the nursery. In 2001 (September 17) these means were 4.97 and 6.42, respectively. Means of contributor lines in 2002 ranged from 2.7 to 5.7.

Cercospora/Curly Top-Resistant Populations with Resistance to Multiple Sugar Beet Diseases and Superior Agronomic Characteristics

Germplasm under Development:

Cercospora Leaf Spot/Curly Top Resistant (LSR/CTR) Breeding Populations Currently under Development.

1. Cercospora leaf spot and curly top resistant monogerm base population from a polycross of FC607 and FC604 with two Salinas germplasms 2859 and 2890.
    1. 2890 (sp) = 0790 *mm aa* x 1890 (Salinas); is seed from *aa* plants open pollinated by A- plants. 0790 = population-790 cycle 5 synthetic by S_1 progeny, *aa*, mm, O-type, good combining ability, adapted to California, S^f. 1890 = BC population to population 790 to get Rz equivalent, remains variable for M-:mm, Rz-:rzrz, etc.
    B. 2859 m (sp) = 1859, 1859R aa x A- (Salinas); Released in 1992 as C859. S^f, similar to 2890, but should have higher curly top resistance. Segregates and variable for M-:mm, Rz-:rzrz, A-:aa, predominant background is lines like C563.

2. Cercospora leaf spot and curly top resistant multigerm base population from a polycross of FC902 with two Salinas germplasms 278 and 4918.
    A. 278 (Iso 83) = RZM R078; R278 is Rz (segregates Rz--:rzrz) version of C46. It should be S^sS^s, MM.
    B. 4918 (sp) = RZM 3918aa X A-, 142 aa plants; This is an increase of released material C918. It should be Multigerm, over 75% S^f and segregating for A-, R-, Rz-, VY, CT, Erw, & PM.

3. Cercospora leaf spot and curly top resistant multigerm, self-incompatible base population from a polycross of FC607 x [SR87, MonoHy A4, MonoHy T6, & MonoHy T7]

4. Seed from FC709-2 x FC907 was sent to Larry Campbell at Fargo to cross to Sugar beet root maggot resistant germplasm to develop a population that will produce pollinators with resistance to *Rhizoctonia, Cercospora*, and Root maggot.

5.	Two tetraploid pollinators (FC6064X and FC6074X) were crossed to a high sucrose tetraploid population in order to produce a tetraploid *Cercospora*-resistant pollinator population with better combining ability.

Progress in 2002

Advanced breeding lines of *Cercospora* resistant germplasms were evaluated in the ARS leaf spot nursery at Ft. Collins. These lines are part of the resistant germplasm development effort in which a new germplasm should be released from the "pipeline" every two to four years. The above populations, currently, are in different stages of development.

1.	Selections were made among half-sib progeny rows (FC607&FC604/2859&2890) of the monogerm population in 2001. Families selected based on combined leaf spot and curly top resistance were increased and tested in 2002. Material sent to Salinas, CA is in the field and show good rhizomania resistance and progeny families are being tested for sucrose. They have been selected for resistance to rhizomania (Holly gene source - *Rz*) and agronomic performance, and are in the second cycle of recombination and evaluation. Selections are also being O-type screened for release (Tables 10 & 11).

2.	Plants (F_2) from the CTR/LSR multigerm cross (2 above – FC902/278/4918.) were tested for resistance to *Rhizoctonia* and *Cercospora* and recombined. This seed has been bulk increased and crossed with a number of other leaf spot, rhizomania resistant and high sources populations. The resulting population will be a source of curly top resistant multigerm pollinators with leaf spot and Rhizomania resistance. This cross was planted in the Salinas nursery for selection for rhizomania resistance and also has been selected for agronomic performance and recombined. It will be tested and evaluated for release.

3.	Plants (F_2) from the Fort Collins and Fargo joint project (3 above – FC607 x [SR87, MonoHy A4, MonoHy T6, & MonoHy T7]) were grown in the breeding nursery and these roots were planted in Masonville and selfed, taking advantage of the 'pseudo self-fertility' that occurs in this environment. This selfed seed was progeny tested in 1999 and the most resistant families were recombined and are being tested and evaluated for release. This population will be a source of highly leaf spot resistant multigerm pollinators with curly top resistance and good combining ability for agronomic traits (See tables 10 & 11 below).

4.	Seed from (FC709-2 x FC907)F_2 has been sent to Larry Campbell at Fargo to cross to Sugar beet root maggot resistant germplasm and be selected for *Cercospora* resistance. This population will be reselected for *Rhizoctonia* resistance. The population will provide pollinators with resistance to *Rhizoctonia*, *Cercospora*, and Root maggot. This material will be screened in Fargo in 2003.

5.	Half-sib families from this population (FC6064X & FC6074X/high sucrose 4X) will be planted in the leaf spot nursery and selected for *Cercospora*-resistance and also tested for sucrose & yield in 2003.

Table 10. Experiment 7A, 2002. Leaf Spot Evaluation of USDA-ARS Fort Collins breeding lines.

Entry	Identification	Entry	Disease Index[1]			
			Sept. 5th	Sept. 14th	Sept. 19th	Sept. 25th
LSD$_{0.05}$			ns	ns	ns	0.87
CV			37.4	24.4	18.7	14.3
LSS[2,4]	(931002)		3.0	4.0	4.5	5.0
LSR[3]	(821051H2)		1.7	3.3	3.7	3.7
Trial Mean			1.7	3.0	3.4	3.7
20011007	F3 (907 x 709-2)sel RhzcR - hs 10A-1775	516	1.0	2.0	2.7	2.7
20011045MS	(SucroseMM x PI540599)F2	519	1.3	2.3	3.0	3.0
20011045PF	(SucroseMM x PI540599)F2	520	1.5	2.7	3.0	3.2
921021	FC703-5	503	1.0	2.7	2.7	3.3
20011002bbMS	LSR (France) x SucroseMM - *aa* biennial segregants	514	1.3	3.0	3.0	3.3
951016HO1	FC723 CMS – EL44/FC708 CMS	511	1.7	2.3	2.7	3.3
20001016H	FC709-2	508	1.0	2.0	3.0	3.3
20011060	[FC712 x 9931(Salinas)] F2	522	1.7	3.0	3.3	3.3
20001016H2	(FC708CMS X FC709-2)	528	1.0	2.3	3.0	3.3
20001022	FC710(4X) - LSR Tetraploid	526	1.7	3.3	3.0	3.7
20001007	LSR w/ Fargo	525	1.7	3.7	4.0	3.7
20001017	FC720-1	524	1.3	2.7	3.7	3.7
951016HO	FC723 – EL44/FC708 mm	510	2.0	2.7	3.3	3.7
951017	FC727	509	1.3	2.7	3.3	3.7
891033	FC710	527	2.0	3.5	3.7	3.7
911026HO	FC715	502	1.3	2.7	3.0	3.7
20011024	CTR/LSRmmpop; FC607, FC604, 2890, & 2859	518	1.7	3.0	3.3	3.7
911043HO1	FC403CMS	534	2.0	3.3	4.0	3.7
20011016	Rhx=zcRmm (991001) (2859 & 2890) X FC708	532	1.7	3.0	3.0	3.7
921022	FC702-7	504	1.7	3.3	3.5	3.7
20011002bbPF	LSR (France) x SucroseMM - *A*- biennial segregants	515	2.0	3.0	3.7	4.0
20011003HO1	FC712/MonoHy A4 - CMS equivalent	531	2.0	3.0	3.7	4.0
961010HO1	FC722 CMS – C718/FC708 CMS	513	2.0	3.3	3.7	4.0
961010HO	FC722-1 – C718/FC708	512	2.3	3.3	4.0	4.0
20011054	(SucroseMM x PI540605)F2	521	1.7	3.3	3.0	4.0
20021002	RhzcR/mR - (FC907 x FC709-2) x 9931	523	1.7	3.3	3.7	4.0

Table 10. Experiment 7A, 2002. Leaf Spot Evaluation of USDA-ARS Fort Collins breeding lines.

Entry	Identification	Entry	Disease Index[1]			
			Sept. 5th	Sept. 14th	Sept. 19th	Sept. 25th
	LSD$_{0.05}$		ns	ns	ns	0.87
	CV		37.4	24.4	18.7	14.3
	LSS [2,4] (931002)		3.0	4.0	4.5	5.0
	LSR [3] (821051H2)		1.7	3.3	3.7	3.7
	Trial Mean		1.7	3.0	3.4	3.7
20011001	LSR Polycross with East Lansing material	529	2.3	3.3	3.3	4.0
20011003HO	FC712/MonoHy A4	530	1.7	2.8	3.3	4.0
981025	FC717	507	1.7	2.7	3.3	4.0
97A050	FC607	506	1.7	3.0	3.7	4.0
831085HO	FC708	501	1.7	3.7	4.0	4.0
20011013H	F4 (907 x 709-2) selRhzcR - sel hs 10A	517	2.0	3.0	3.7	4.0
921025	FC728	505	2.3	3.3	3.7	4.2
911043HO	FC403	533	2.7	4.0	4.3	4.3

[1] Disease Index is based on a scale of 0 (=healthy) to 10 (=dead).
[2] The Leafspot Susceptible Check is SP351069-0.
[3] The Leafspot Resistant Check is ((FC504CMS x FC502/2) x SP6322-0).
[4] The Leafspot Susceptible Check was missing one plot but LSD was calculated as if all three plots were there.

Table 10. Experiment 7A, 2002. Leaf Spot Evaluation of USDA-ARS Fort Collins breeding lines.

Entry	Identification	Entry	Disease Index[1]			
			Sept. 5th	Sept. 14th	Sept. 19th	Sept. 25th
	LSD0.05		ns	ns	ns	0.87
	CV		37.4	24.4	18.7	14.3
	LSS[2,4] (931002)		3.0	4.0	4.5	5.0
	LSR[3] (821051H2)		1.7	3.3	3.7	3.7
	Trial Mean		1.7	3.0	3.4	3.7
20021002	RhzcR/mR - (FC907 x FC709-2) x 9931	523	1.7	3.3	3.7	4.0
20011001	LSR Polycross with East Lansing material	529	2.3	3.3	3.3	4.0
20011003HO	FC712/MonoHy A4	530	1.7	2.8	3.3	4.0
981025	FC717	507	1.7	2.7	3.3	4.0
97A050	FC607	506	1.7	3.0	3.7	4.0
831085HO	FC708	501	1.7	3.7	4.0	4.0
20011013H	F4 (907 x 709-2) selRhzcR - sel hs 10A	517	2.0	3.0	3.7	4.0
921025	FC728	505	2.3	3.3	3.7	4.2
911043HO	FC403	533	2.7	4.0	4.3	4.3

[1]Disease Index is based on a scale of 0 (=healthy) to 10 (=dead).
[2]The Leafspot Susceptible Check is SP351069-0.
[3]The Leafspot Resistant Check is ((FC504CMS x FC502/2) x SP6322-0).
[4]The Leafspot Susceptible Check was missing one plot but LSD was calculated as if all three plots were there.

Table 11. Breeding lines from the USDA-ARS Fort Collins breeding program tested in the BSDF Curly Top Nursery in Kimberly, ID in 2002.

Seed Source	Description		Disease Index*	
			Aug 27	Sept 10
	EXPERIMENT MEAN		2.65	2.90
96A008	Beta G6040 - Resistant Check		2.00	2.00
931017	Susceptible Check - FC901/C817		2.83	2.83
		CV	22.2	23.8
		LSD	ns	1.113
20001022	FC710(4X) - LSR Tetraploid		2.00	2.17
86A047	FC607CMS (4x)		2.50	2.17
831028HO	FC506		2.17	2.17
941029HO	FC401		2.33	2.17
1997A051	FC607CMS		2.00	2.33
911037	FC719		2.00	2.33
20011009	FC702-4(4X)		2.50	2.33
951016HO	FC723 – EL44/FC708 mm		2.50	2.33
951016HO1	FC723 CMS – EL44/FC708 CMS		2.50	2.33
86A045	FC606CMS (4x)		2.33	2.33
741026H	High Sucrose x maritima		2.17	2.33
20011008HO	FC502-2		2.17	2.33
19931012	FC901		2.17	2.33
991015	FC801		2.33	2.50
20001016H	FC709-2		2.83	2.50
20001019	FC705		2.50	2.50
911043HO1	FC403CMS		2.17	2.50
20011054	(SucroseMM x PI540605)F$_2$		2.67	2.50
2002A035	HM9155		2.33	2.50
20001016H2	(FC708CMS X FC709-2)		2.58	2.50
911026HO	FC715		2.33	2.50
86A046	FC606 (4x)		2.50	2.50
1987A026	AD1 (4x)		2.67	2.50
19951029	AD3 (4x)		2.33	2.50
951017	FC727		2.17	2.50
831085HO	FC708		3.00	2.50
20011045PF	(SucroseMM x PI540599)F$_2$		2.50	2.67
971020	FC907-1 – FC607/FC701 BC4 - 1 cycle RhzcR sel		2.17	2.67
781079H	High Sucrose Polish		2.33	2.67
2001A016	SR94; WC960448		2.67	2.67
2001A014	SR96; WC980437		2.50	2.67
2001A017	SR93; WC980438		2.33	2.67
811055H	FC702-6		2.83	2.67
931005HO	FC721		3.50	2.67
20011013H	F4 LSR MM x RhzcR/LSR - sel hs 10A		2.50	2.67
781035HO	FC606		2.50	2.67
891037	AD2 (4x)		2.67	2.67
821087	FC711		2.67	2.67
20011045MS	(SucroseMM x PI540599)F$_2$		2.58	2.67
821051H2	LSR		2.33	2.67
911042HO1	FC402CMS		2.33	2.67
2001A013	EL0204		2.50	2.67
991016	FC702/2		2.33	2.83
20011001	LSR Polycross with East Lansing material		2.33	2.83

Table 11. Breeding lines from the USDA-ARS Fort Collins breeding program tested in the BSDF Curly Top Nursery in Kimberly, ID in 2002.

Seed Source	Description	Disease Index* Aug 27	Disease Index* Sept 10
	EXPERIMENT MEAN	2.65	2.90
96A008	**Beta G6040 - Resistant Check**	**2.00**	**2.00**
931017	**Susceptible Check - FC901/C817**	**2.83**	**2.83**
	CV	22.2	23.8
	LSD	ns	1.113
2002A036	**Monohikarí**	**2.33**	**2.83**
781035HO1	**FC606CMS**	**2.83**	**2.83**
891033	**FC710**	**2.50**	**2.83**
731028HO	**FC902**	**2.50**	**2.83**
20001025HO1	**FC604CMS**	**2.67**	**2.83**
911042HO	**FC402**	**2.83**	**2.83**
20001007	**LSR w/ Fargo**	**2.83**	**2.83**
961010HO	**FC722-1 – C718/FC708**	**2.67**	**2.83**
20001025HO	**FC604**	**2.67**	**2.83**
921022	**FC702-7**	**2.67**	**2.83**
20001017	**FC720-1**	**2.83**	**2.83**
20011002bbMS	**LSR (France) x SucroseMM - *aa* biennial segregants**	**2.83**	**2.92**
931010	**FC726**	**2.67**	**2.92**
771052	**Low amino-N population**	**3.33**	**3.00**
20001020	**FC706**	**2.83**	**3.00**
931005HO1	**FC721CMS**	**3.00**	**3.00**
97A004	**EL 48**	**2.17**	**3.00**
19991017	**FC703**	**2.50**	**3.00**
20001021	**FC707**	**2.67**	**3.00**
971018	**FC712(4X)**	**2.33**	**3.00**
921008	**FC725**	**2.67**	**3.00**
961014	**FC724-1 – FC702/LSR-CTR**	**2.67**	**3.00**
971019	**FC716**	**2.42**	**3.08**
2001A018	**SR80; WC980436**	**2.33**	**3.17**
961010HO1	**FC722 CMS – C718/FC708 CMS**	**3.00**	**3.17**
751080H	**FC703**	**2.83**	**3.17**
19991018	**FC709**	**2.83**	**3.17**
20011007	**F3 LSR MM x RhzcR/LSR (907 x 709-2)**	**2.17**	**3.17**
2001A020	**94HS25; WC960452; smooth root**	**2.50**	**3.17**
86A048	**FC607 (4x)**	**2.50**	**3.17**
2001A020	**94HS25; WC960452**	**2.83**	**3.17**
2001A019	**SR87; WC960444**	**2.83**	**3.17**
921019	**FC729 – FC712/A4, 3 cycles Rhizoc, MM**	**3.33**	**3.33**
79A067	**FC607**	**2.58**	**3.33**
2002A037	**Beta 6045**	**3.00**	**3.33**
911043HO	**FC403**	**3.00**	**3.33**
20011002bbPF	**LSR (France) x SucroseMM - A- biennial segregants**	**3.00**	**3.33**
19911041HO1	**FC401CMS**	**3.00**	**3.33**
921025	**FC728**	**2.33**	**3.33**
981025	**FC717**	**2.83**	**3.33**
20011024	**CTR/LSRmmpop; FC607, FC604, 2890, & 2859**	**2.83**	**3.50**
801059H	**FC701-6**	**2.83**	**3.50**
751132	**Russian Multi-germ Germplasm Pool**	**3.17**	**3.50**

Table 11. Breeding lines from the USDA-ARS Fort Collins breeding program tested in the BSDF Curly Top Nursery in Kimberly, ID in 2002.

Seed Source	Description		Disease Index*	
			Aug 27	Sept 10
	EXPERIMENT MEAN		2.65	2.90
96A008	Beta G6040 - Resistant Check		2.00	2.00
931017	Susceptible Check - FC901/C817		2.83	2.83
		CV	22.2	23.8
		LSD	ns	1.113
2001A015	SR95; WC970308		2.83	3.50
20011060	[FC712 x 9931(Salinas)] F$_2$		3.00	3.58
20001018	FC704		3.67	3.67
921021	FC703-5		2.50	3.67
931024	FC701		3.17	3.83
771067HO	FC504		3.00	3.83
911032	FC718		3.33	3.83
831083	FC705/1		3.50	3.83
761068H	FC701-4		3.17	4.17
751099H	L-19		3.67	4.17
881032H	FC712		3.67	4.17

*Disease Index (DI) scale = 0 (no symptoms) to 9 (plant death).

Pre-breeding: the Introgression of New Sources of Cercospora Leaf Spot Resistance from *Beta Vulgaris* ssp. *maritima* and Other Exotic Sources into Sugar Beet-type Populations (BSDF Project 443)

Lee Panella

USDA-ARS Fort Collins, Colorado

A major emphasis of the research mission of the USDA-ARS plant scientists is the collection, documentation, characterization, evaluation, regeneration (maintenance), distribution, and utilization of plant germplasm, especially Plant Introduction (PI) accessions in the USDA-ARS National Plant Germplasm System (NPGS). The Sugar Beet Research Unit at Fort Collins is coordinating the national program for *Beta* germplasm evaluation. In addition to the evaluation for *Rhizoctonia* and *Cercospora* resistance, it is crucial that the ARS scientist be involved in the long range, high risk research problems involved in sugar beet 'germplasm enhancement' or 'pre-breeding' from exotic germplasm or wild relatives of cultivated species. This is an important component in the overall sugar beet improvement effort of the Fort Collins Sugarbeet Research Unit.

Justification for Research:

Cercospora leaf spot (caused by the fungus *Cercospora beticola* Sacc.) is one of the most widespread diseases of sugar beet and is a serious problem in many sugar beet production areas throughout the U.S. The disease damages the leaves, which, consequently, reduces root yield, percent sucrose of roots, and purity of the extracted juice. Cercospora leaf spot currently is controlled by combining spraying with commercial fungicides and the use of disease tolerant germplasm. The development of Cercospora leaf spot resistant sugar beet lines and hybrids with greater levels of host-plant resistance offers a more sustainable solution to this disease problem.

If the level of resistance available in some *Cercospora*-resistant experimental breeding lines were present in commercial hybrids (along with good sugar and seed yield), the need for fungicides could be greatly reduced. That continued improvement in genetic resistance to this serious pathogen is still needed is evident by the occurrence of *Cercospora* strains that are tolerant to our most potent fungicides. Additionally, some fungicides may be removed from the market because of their perceived or real threat to the environment.

Finally, the genepool for resistance to Cercospora leaf spot is extremely narrow. Many of the resistant lines are highly inbred, therefore, closely related to one another, and stem from germplasm coming out of Italy in the early 1900s. In the germplasm developed at Fort Collins, continued inbreeding has increased the level of disease resistance, but at the cost of plant vigor. Over the long term, a secure, sustainable response to this disease requires commercial quality hybrids with good host-plant resistance.

Objectives:

1.   The formation of long range breeding populations through the introgression of *Cercospora* resistant germplasm from "exotic" sources (*Beta vulgaris* ssp. *maritima*, fodder beet, foreign sugar beet landraces from the PI collection, etc.).

2.   The development of germplasm populations from these long range populations that are of

sufficient agronomic quality to be of use to commercial breeders. They will be a source of leaf spot resistance with and within differing genetic backgrounds.

3.   The development of techniques (both traditional and molecular) to more efficiently introgress the exotic germplasm into sugar beet breeding populations.

Research Progress 2002:

We have increased or made crosses in eighteen populations listed below (See table 13 below). All of the male parents are germplasm that have been identified as having resistance to *Cercospora beticola* (causal agent of Cercospora leaf spot). The female parents are from a population developed to have high sucrose yield potential. These sucrose populations are based on old commercial varieties – i.e., MonoHy T6, A7, A4 and breeding lines received from American Crystal Sugar Co. and Seedex, Inc. – and USDA-ARS developed germplasm such as L-19 (WC9127OM) and East Lansing smooth root germplasm, SR87. Other parents include high sucrose germplasm from Poland and other Eastern European countries. Salinas parent '3859' was used to produce populations that are self-fertile (S^f) and segregating for nuclear male sterility ($A-:aa$). The families from various crosses are in different stages of development and evaluation. At the F_3 stage, when sufficient seed is available, we are beginning field screening and selection. Seed of these families has been bulk increased and is beginning to be evaluated. All show some annual plants in our environment and are being selecting for the nonbolting types.

We are re-crossing some of those from which we obtained insufficient F_1 seed. Plants from those populations producing some biennial plants are being vernalized for 90 days and the populations are being increased (i.e., random mated using the genetic male sterility where possible). The annuals will be handled in a similar fashion once the F_1 populations have been increased. All will be cycled through at least three cycles of random mating.

The most advanced populations were screened for resistance to Cercospora leaf spot and curly top (Tables 10 11, & 12). Evaluations have shown that some of the populations have good levels of resistance to leaf spot and some of the populations may also have resistance to the curly top virus. All of the populations are still segregating for biennial growth habit, easy bolting, and other traits typical of wild beets.

Table 12. Experiment 7A, 2001. Leaf Spot Evaluation of USDA-ARS Fort Collins, Salinas, and East Lansing breeding lines.

Entry	Identification	Disease Index[1]			
		Sept. 3rd	Sept. 10th	Sept. 17th	Sept. 24th
$LSD_{0.05}$		1.05	1.24	1.15	1.21
CV		23.6	22.3	15.0	19.4
LSS [2] (931002)		4.3	5.3	6.0	5.7
LSR [3] (821051H2)		2.7	2.3	4.8	4.0
Trial Mean		2.7	3.4	4.7	3.8
Sucrose MMaa population X PI535826 (Giant Poly - LSR)	991026MS	2.3	2.3	4.0	3.8
Sucrose MMaa X LSR PI540596 - biennial maritima LSR	981032	2.7	3.7	4.3	3.7
Sucrose MMaa population X PI535826 (Giant Poly - LSR)	991026PF	3.2	3.2	4.5	3.3
Sucrose MMaa X LSR PI540599 - annual maritima LSR	981033PF	3.3	4.8	5.3	4.7

[1]Disease Index is based on a scale of 0 (=healthy) to 10 (=dead).
[2]The Leafspot Susceptible Check is SP351069-0.
[3]The Leafspot Resistant Check is ((FC504CMS x FC502/2) x SP6322-0).

Advanced and experimental germplasm from the USDA-ARS Fort Collins breeding program tested in the BSDF Curly Top Nursery in Kimberly, ID in 2001.

Donor's ID	Identification	Entry	Disease Index*	
			17 Aug	31 Aug
Beta G6040 - Resistant Check	96A008	224	5.0	4.7
FC718 - Susceptible Check	911032	225	7.3	7.3
Sucrose MMaa X LSR PI540596 - biennial maritima LSR	981032	179	5.7	6.3
Sucrose MMaa population X PI535826 (Giant Poly - LSR)	991026MS	182	6.5	7.0
Sucrose MMaa population X PI535826 (Giant Poly - LSR)	991026PF	183	6.7	7.3
Sucrose MMaa X LSR PI540599 - annual maritima LSR	981033PF	180	6.5	8.0

*Disease Index (DI) scale = 0 (no symptoms) to 9 (plant death).

Table 13. List of germplasm used in developing Cercospora leaf spot resistant populations and the stage of each of the populations.

Acc. No. (♂)	♀ parent	Donor (♂) Designation	Name or Origin (♂)	% ♂ Bolting no induction 1996 FC, CO	F₁ Population	F₂ Pop.	F₃ Pop.	F₄ Pop.	F₅ Pop.
96A012	961005	PI 535843	PN MONO 1	100%	971026H2[1]				
96A013	961005	PI 540575	WB 829	100%	971027H2[2]				
96A016	961005	PI 540599	WB 853	50%	971028H2	981033PF / 981022MS	20011045bbPF / 20011045bbMS	20031023	
94A079	961005	BGRC #32375 ssp. *maritima*	Greece	annual	971029H2	20011036			
94A080	961005	BGRC #36538 ssp. *maritima*	Greece	annual	971030H2[3]	20011037			
94A081	851046HO	BGRC #45511 ssp. *maritima*	Greece	annual	981001H3	20011038B- / 20011038bb			
94A081 / 981001H	961005 / 19991024H2	BGRC #45511 ssp. *maritima*	Greece	annual	2001046H2	20021036B- / 20021036bb			
94A082	851046HO	BGRC #45516 ssp. *maritima*	Greece	annual	981002H3	20011039B- / 20011039bbPF / 20011039bbMS			
94A082 / 981002H	961005 / 19991024H2	BGRC #45516 ssp. *maritima*	Greece	annual	--- / 20021033H2				
94A083	961005	BGRC #48810 ssp. *maritima*	Tunisia	annual	1981003H2	20011040B- / 20011040bb	20021030B- / 20021030bb	20031038B- / 20031038bb	
94A083	851046HO	BGRC #48810 ssp. *maritima*	Tunisia	annual	981003H3	20011041B- / 20011041bb			
94A084	961005	BGRC #48819 ssp. *maritima*	Tunisia	annual	981004H2	20011042B- / 20011042bb	20021031B- / 20011031bb	20031039B- / 20031039bb	
94A084 / 981004H	961005 / 19991024H2	BGRC #48819 ssp. *maritima*	Tunisia	annual	--- / 20021034H2				
94A085 / 981005H	961005 / 19991024H2	BGRC #51430 ssp. *maritima*	Greece	annual	--- / 20021035H2				

[1]Only 16 seed balls produced.
[2]Only 10 seed balls produced.
[3]Only 60 seed balls produced.

Summary of Literature Review:

Cercospora leaf spot has been an intermittent problem in sugar beet growing areas of the United States where the summers can be hot and humid (Red River Valley, Michigan, Ohio, and, less often, Great Plains growing areas and California). It has been estimated that a severe epidemic can cause up to a 42% loss of gross sugar (Smith and Martin, 1978; Smith and Ruppel, 1973), or up to a 43% relative dollar loss (Shane and Teng, 1992).

Resistance to *Cercospora* has long been a goal of the USDA-ARS sugar beet research program at Fort Collins and researchers there developed the techniques necessary to manage the screening nurseries in such a way as to promote the development of the disease (Ruppel and Gaskill, 1971). A careful crop rotation (sugar beet-barley-barley-barley-sugar beet) and the arid climate and low relative humidity have allowed this to be done in such a manner that there are rarely high enough levels of any other disease present in the leaf spot nursery to confound the results. The resistance to *Cercospora* could more accurately be described as a tolerance, rather than true resistance. Tolerance or "field resistance" means that, although some symptoms of the disease are present, the plant still is able to perform well (Fehr, 1987 p.307).

Much of the *Cercospora*-resistant germplasm in use today came out of Munerati's program in Italy, in which *B. vulgaris* ssp. *maritima* was the source of resistance genes (Lewellen, 1992). In this genetic source, there are an estimated 4 or 5 genes responsible for leaf spot resistance (Smith and Gaskill, 1970) and broad-sense heritability estimates ranged from 12 to 71% (Bilgen et al., 1969). Narrow-sense heritability estimates of about 24% compared well with realized heritability values, and 44 to 62% of the variation was due environment in this test (Smith and Ruppel, 1974). The large environmental variation has made it difficult to make progress in developing resistance through mass selection. Incorporation of high levels of leaf spot resistance into varieties with superior agronomic performance also is difficult (Smith and Campbell, 1996) and, therefore, commercial resistant varieties require some fungicide application to provide adequate levels of protection against *Cercospora* (Miller et al., 1994).

A major problem in the development of *Cercospora*-resistant sugar beet is the loss of vigor due to the continual inbreeding. Coons (1955) noted this and it has been a concern ever since (McFarlane, 1971). The use of hybrid varieties has ameliorated this problem to some extent, but seed production on the highly inbred O-type males and CMS females still is a problem. This creates an urgent need to continue to develop a broader genetic base in our CLS-resistant germplasm than we have today. Also as commercial hybrid parents become more inbred, the germplasm base from which these inbred parents are developed must have the diversity necessary to provide for maximum gain through heterosis. In addition to broadening the genetic base of the commercial sugar beet germplasm, novel genes for resistance to Cercospora leaf spot might lead to transgression of the currently available *Cercospora* tolerance. Simply defined, transgression is when a population contains individuals with a phenotype that is beyond the phenotype found in the parents of the population (de Vicente & Tanksley, 1993).

The USDA-ARS National Plant Germplasm System *Beta* collection has over 2,000 Plant Introduction (PI) accessions. The germplasm used most often in sugar beet breeding is from *Beta vulgaris* ssp. *vulgaris*, which includes all of the biennial sugar beet types, or from *Beta vulgaris* ssp. *maritima*, which contains the closely related wild sea beet and has both annual and biennial types. Germplasm with a biennial flowering habit is easier both to introgress and screen. *Beta vulgaris* ssp. *maritima* has, nonetheless, been used as a source of resistant germplasm. Much of the *Cercospora-*

resistant germplasm in use today, which came out of Munerati's program in Italy, had *B. vulgaris* ssp. *maritima* as the source of resistance genes (Lewellen, 1992). There have been very few new efforts to locate and incorporate other sources of resistance to *Cercospora* into this narrow germplasm base. Munerati's success, and the research of others, has shown that it can be done if we have the persistence to do it (Bilgen et al., 1969; Doney, 1993; Lewellen, 1995).

References

Bilgen, T., J.O. Gaskill, R.J. Hecker, and D.R. Wood. 1969. Transferring *Cercospora* leaf spot resistance from *Beta maritima* to sugarbeet by backcrossing. J. Am. Soc. Sugar Beet Technol. 15:444-449.

Coons, G.H., F.V. Owen, and D. Stewart. 1955. Improvement of the sugar beet in the United States. Adv. Agron. 7:89-139.

de Vicente, M. C. and S. D. Tanksley. 1993. QTL analysis of transgressive segregation in an interspecific tomato cross. Genetics 134(2), 585-596.

Doney, D.L. 1993. Broadening the genetic base of sugarbeet. J. Sugar Beet Res. 30:209-220.

Fehr, W. R. 1987. *Principles of Cultivar Development.* 1st ed. Vol. 1. Macmillan Publishing Company, New York. 536 pages.

Lewellen, R.T. 1992. Use of plant introductions to improve populations and hybrids of sugarbeet, p. 117-135. In: Use of Plant Introductions in Cultivar Development. Crop Science Society of America, Madison, WI.

Lewellen, R.T. 1995. Performance of near-isolines of sugarbeet with resistance to Rhizomania from different sources. Proceedings of the 58th Congress of the International Institute for Beet Research. pp.83-92. Presses Universitaires de Bruxelles a.s.b.l., Bruxelles.

McFarlane, J.S. 1971. Variety development, p. 402-435. In: R.T. Johnson, J.T. Alexander, G.E. Rush, and G.R. Hawkes (eds.). Advances in Sugarbeet Production: Principles and Practices, 1st ed. The Iowa State University Press, Ames, IA.

Miller, J., M. Rekoske, and A. Quinn. 1994. Genetic resistance, fungicide protection and variety approval policies for controlling yield losses from Cercospora leaf spot infections. J. Sugar Beet Res. 31:7-12.

Ruppel, E.G. and J.O. Gaskill. 1971. Techniques for evaluating sugarbeet for resistance to *Cercospora beticola* in the field. J. Am. Soc. Sugar Beet Technol. 16:384-389.

Shane, W.W. and P.S. Teng. 1992. Impact of Cercospora leaf spot on root weight, sugar yield, and purity of *Beta vulgaris*. Plant Dis. 76:812-820.

Smith, G.A. and L.G. Campbell. 1996. Association between resistance to *Cercospora* and yield in commercial sugarbeet hybrids. Plant Breeding 115:28-32.

Smith, G.A. and J.O. Gaskill. 1970. Inheritance of resistance to Cercospora leaf spot in sugarbeet. J. Am. Soc. Sugar Beet Technol. 16:172-180.

Smith, G.A. and S.S. Martin. 1978. Differential response of sugarbeet cultivars to Cercospora leaf spot disease. Crop Sci. 18:39-42.

Smith, G.A. and E.G. Ruppel. 1973. Association of Cercospora leaf spot, gross sucrose, percentage sucrose, and root weight in sugarbeet. Can. J. Pl. Sci. 53:695-696.

Smith, G.A. and E.G. Ruppel. 1974. Heritability of resistance to *Cercospora* leaf spot in sugarbeet. Crop Sci. 14:113-115.

Materials and Methods:

Artificial field inoculation with *Cercospora beticola* and leaf spot scoring will be used to identify the resistant germplasm sources and make selections in the developing populations. The exotic materials will be crossed into sugar beet populations that have been selected for agronomic quality (recoverable sucrose yield). These sucrose populations are based on old commercial varieties (i.e., MonoHy T6, A7, A4), donated breeding lines from American Crystal Sugar Co. and Seedex, Inc., and USDA-ARS developed germplasm such as L-19 (WC9127OM) and East Lansing smooth root germplasm, SR87. Other parents include high sucrose germplasm from Poland and other Eastern European countries. Salinas parent '3859' was used to produce populations that are self-fertile (S^f) and segregating for nuclear male sterility (A-:aa).

Hybrid populations will be handled in the following manner: 1) Following the initial cross, a population will be random mated (using *aa* females because of the self-fertility) for three to four generations to break up linkage groups and remove annual plants. 2) Sugar beet-type mother roots will be selected, selfed, and progeny tested for agronomic performance and disease resistance. 3) Selected roots will be recombined (and backcrossed if desirable) and re-selected until they ready for release. Molecular markers (RFLPs, RAPDs, SSRs, AFLPs, etc.) as they become available will be used to expedite the backcrossing program and to follow the change in allele frequencies in the selected populations. Advanced populations will be released to the sugar beet seed industry.

SUGARBEET RESEARCH

2002 Report

SECTION C

U.S. Department of Agriculture, Agricultural Research Service, Northern Crop Science Laboratory, Sugarbeet & Potato Research Unit, 1307 N 18th St., P.O. Box 5677, Fargo, North Dakota 58105-5677

Telephone Number: (701) 239-1350
Fax Number: (701) 239-1349

SUGARBEET AND POTATO RESEARCH UNIT

Dr. J.C. Suttle, Research Leader
    Plant Physiologist
Dr. L.G. Campbell, Geneticist
Mr. J.D. Eide, Plant Physiologist
Dr. T.L. Friesen, Plant Pathologist
Dr. K.L. Klotz, Plant Physiologist
Ms. R.L.Stolzenberg, Microbiologist
Dr. J. J. Weiland, Plant Pathologist

Cooperation:

North Dakota State University, Fargo, ND
Sugarbeet Research and Education Board of MN and ND
University of Minnesota, Crookston, MN
USDA, Agriculture Research Service, Fort Collins, CO

———————

CONTENTS

PUBLICATIONS
Abstract of Papers Presented or Published

Campbell, L.G., Klotz, K.L. Impact of root diseases on post-harvest storage. Abstracts of Joint Meeting of International Institute for Beet Research and the American Society Sugar Beet Technologists. 2003. p. 59 Abstr.

In recent years, sugarbeet (Beta vulgaris L.) root diseases have become more prevalent throughout Minnesota and eastern North Dakota. Any increase in root rots in the field will be accompanied by an increase in the proportion of roots with rot that are placed in storage piles. Information on the effects of root-rot severity on initial quality and storability would assist growers and agriculturalists when determining the disease severity that would justify not harvesting a field or if roots from diseased fields should be segregated and processed first. Respiration rates of roots with moderate or severe Aphanomyces (caused by Aphanomyces cochlioides Drechal.) were substantially higher than respiration rates of healthy roots. The higher respiration rates are not only indicative of higher sugar loss but would increase storage pile temperatures and increase sugar losses of adjacent healthy roots. The formation of carbohydrate impurities during post-harvest storage was examined. Concentrations of the invert sugars, glucose and fructose, were elevated in severely rotted roots. Invert sugar concentrations, however, changed little during storage regardless of disease severity. Trisaccharide impurities declined during storage in both healthy and diseased roots and were lower in diseased roots. Raffinose was the major trisaccharide, although 1-kestose and 6-kestose also were detected in severely rotted roots. Neither Rhizomania (Beet Necrotic Yellow Vein Virus) nor Aphanomyces resistance appeared to be associated with higher respiration rates, in the absence of the disease.

Campbell, L.G., Klotz, K.L. Impact of root diseases on storage. 2002 Sugarbeet Research and Extension Reports, Cooperative Extension Service, North Dakota State University. 2003. v.33 p. 254-257.

In recent years, the sugarbeet (Beta vulgaris L.) root diseases, Aphanomyces and rhizomania (causal agents Aphanomyces cochlioides Drechal. and Beet Necrotic Yellow Vein Virus, respectively), have become more prevalent throughout Minnesota and eastern North Dakota. Accompanying any increase in root disease in the field will be an increase in the proportion of diseased roots placed in storage piles. Information on the effects of root disease on initial quality and storability would, therefore, assist growers and agriculturalists when determining the disease severity that would justify not harvesting a field or if roots from diseased fields should be segregated and processed first. Respiration rate and extractable sucrose per ton were determined for roots exhibiting varying degrees of Aphanomyces or rhizomania symptoms. Respiration rates of roots with moderate or severe Aphanomyces were substantially higher than respiration rates of healthy roots.

Initial observations of the effects of rhizomania on sugarbeet root storage properties suggest that rhizomania is not nearly as detrimental to root storability as Aphanomyces, however, this indication is based on limited data. The impact of genetic resistance on storage properties appeared to be negligible as neither rhizomania nor Aphanomyces resistance was associated with higher respiration rates in the absence of disease.

Campbell, L.G. Sugar beet breeding and improvements. In: Crop Improvement Challenges in the Twenty-First Century. Kang, Manjit S, editor. Food Products Press, An Imprint of the Haworth Press, Inc. New York, London, Oxford. 2002 p. 193-221.

The commercial production of any plant species depends upon the availability of cultivars that meet the needs of producers, processors, and consumers. Development of new cultivars is a continual process due to the demands for greater productivity, higher quality, and improved pest resistance. Cultivar development is a time consuming laborious process. Plant breeders must strive to design a strategy for cultivar improvement that optimizes utilization of available resources. This article will assist sugarbeet (Beta vulgaris) breeders, especially those entering the field or initiating a new program, in achieving that objective. The major areas covered are; Plant Characteristics and Inheritance, Hybrid Production, Selection Techniques, Agronomic Traits, and Germplasm Resources. The numerous literature citations will facilitate the exploration of specific topics in more detail.

Campbell, L.G. Sugarbeet quality improvement. Journal of Crop Production. 2002. v 5 (1/2) (#9/10) p. 395-413 and simultaneously in Quality Improvement in Field Crops. Basra, A.S. and Randhawa, L.S. editors. Food Products Press, An Imprint of the Haworth Press, Inc. New York, London, Oxford. p 395-413.

More than one third of the sucrose (sugar) consumed by humans is obtained from sugarbeet (Beta vulgaris L.). Sucrose extraction begins with the production of a dark opaque juice from strips of sugarbeet. This juice is purified with lime and carbon dioxide, thickened by evaporation, and crystallized under a vacuum. Soluble non-sucrose constituents of sugarbeet, referred to collectively as impurities, impede sucrose crystallization in normal factory processes. Sucrose concentration and the ratio of sucrose to total soluble solids (sucrose plus impurities) determine processing quality of sugarbeet. Among the more important impurity components are sodium, potassium, and amino- nitrogen. Sucrose and impurity concentrations can be alter in breeding programs. However, a negative association between root yield and sucrose concentration and interactions among impurity components and between impurity components and yield or sucrose concentration have complicated breeding efforts. Also, almost any cultural practice may affect the quality of the crop. Nitrogen fertilizer management is a challenge wherever sugarbeet is grown. Producers' returns can be increased with proper nitrogen application but even

moderate over- fertilization may result in a costly reduction in crop quality. Both producers and processors operate on small profit margins. In this economic environment, producing a high quality crop is a necessity.

Klotz, K.L., Campbell, L.G. Comparison of sucrose catabolism in roots of three Beta vulgaris L genotypes with different yield and sucrose accumulating capacities. Abstracts of Joint Meeting of International Institute for Beet Research and the American Society Sugar Beet Technologists. 2003. Abstr. p. 60.

Sucrose catabolism is a major determinant of sink strength in nearly all plants and affects sucrose partitioning to growing sinks as well as sink size and carbohydrate content. Three major enzyme families are responsible for sucrose catabolism in sugarbeet roots: acid invertase, alkaline invertase and sucrose synthase. Previous work suggested that sucrose synthase may have a role in sink strength and root size in sugarbeet. To examine this observation more thoroughly, sucrose catabolism was compared in three Beta vulgaris genotypes with varying capacities for root yield and sucrose accumulation. Soluble acid invertase, cell wall acid invertase, alkaline invertase and sucrose synthase activities were compared at five stages of root development in a fodder beet hybrid (high yield, low sucrose content), a commercial sugarbeet hybrid (typical yield and sucrose content) and the sugarbeet breeding line, L19 (low yield, high sucrose content). Sucrose, glucose and fructose concentrations and mass accumulation were also determined. Generally, sucrolytic activity was greatest in the high yielding fodder beet and lowest in the low yielding L19 breeding line at any stage of development. Nearly all sucrolytic activity for all genotypes was due to sucrose synthase activity. Sucrose synthase activity was the predominant sucrolytic activity at all the stages of development examined, and accounted for 90% or more of the total sucrolytic activity in fodder beet and sugarbeet roots by six weeks after planting and in L19 eight weeks after planting. Differences in sucrose concentration between genotypes were observed and these were inversely correlated with soluble acid invertase activity. The differences in sucrose concentration, however, were largely differences in water content. Only L19 exhibited a significant increase in sucrose concentration when differences in water content were taken into account.

Klotz, K.L., Anderson, M.D. Contribution of cytochome c and alternative oxidase pathways to respiratory sucrose loss in postharvest sugarbeet (Beta vulgaris L.) roots. Abstracts of Joint Meeting of International Institute for Beet Research and the American Society Sugar Beet Technologists. 2003. Abstr. p. 67.

It is estimated that cellular respiration is responsible for 50 to 70% of the sucrose loss that occurs during postharvest storage of sugarbeet roots. Respiration occurs to provide the metabolic energy and carbon substrates needed to maintain healthy tissue during storage, heal wounds acquired during harvest and defend against pathogens.

Two respiratory pathways, the cytochrome c oxidase pathway and the alternative oxidase pathway, contribute to total respiration. In sugarbeet, little information is available on the role of these two pathways in sucrose utilization and postharvest sucrose loss. This information, however, may prove useful to not only improve our understanding of this physiological process but may potentially provide insight into methods to reduce postharvest respiratory sucrose loss. Analyses of the changes in total respiration and the contribution of the two pathways in sugarbeet roots subjected to different storage conditions and durations, and in response to typical harvest stresses are in progress. Initial results indicate that the cytochrome c respiratory pathway predominates in healthy, nonstressed sugarbeet roots, as has been observed in most other plant species. Respiration is also greatest at the root surface. Oxygen utilization by epidermal tissue was approximately 3- to 4-fold higher than by internal cortical tissue, consistent with the idea that a higher level of energy is needed at the surface of the sugarbeet root for repair of mechanical damage and defense against pathogen attack.

Klotz, K.L. Finger F.L. Contribution of invertase and sucrose synthase isoforms to sucrose catabolism in developing sugarbeet roots. Journal of Sugarbeet Research. 2002. v. 39 p. 1-24.

Sugarbeet roots contain at least seven different sucrolytic activities throughout their development. Two soluble acid invertase isoenzymes, an insoluble acid invertase activity, two alkaline invertase isoenzymes and two sucrose synthase isoenzymes have been identified. Each enzyme had a unique pattern of developmental expression. Soluble and insoluble acid invertase activities were the predominant sucrolytic activity in roots of young seedlings and declined rapidly as the root aged. Soluble acid invertase activity was due primarily to the activity of a single isoenzyme. A second minor isoenzyme of soluble acid invertase was evident only in the earliest stages of development. High soluble and insoluble acid invertase activities were found concurrent with a rapid growth rate, high glucose levels and minimal sucrose accumulation. Sucrose synthase was the major sucrolytic activity during most of the root's development. One sucrose synthase isoenzyme was present throughout development. A second isoenzyme was evident as the roots approached maturity. Nearly all sucrose accumulation and enlargement of the taproot occurred when sucrose synthase was the predominant sucrolytic activity. Alkaline invertase was a minor sucrolytic activity, and was present at low relatively constant levels at all but the earliest stages of development. The relationship of these sucrolytic isoenzymes to growth, sink strength and sucrose storage in sugarbeet roots is discussed.

Klotz, K.L., Finger, F.L., Shelver, W.L. Characterization of two sucrose synthase isoforms in sugarbeet root. Plant Physiology and Biochemistry. 2003. v. 41(2) p. 107-115.

Two sucrose synthase isoforms (ED 2.4.1.13) have been identified in developing sugarbeet (Beta vulgaris L.) roots. To aid in understanding the physiological

significance of these multiple sucrose synthase isoforms, the two isoforms were partially purified and some of their physical and kinetic properties determined. Both isoforms were tetrameric proteins with native molecular weights of 320 kDa. The isoforms exhibited similar kinetic properties as well as similar changes in activity in response to changes in temperature. The isoforms differed, however, in their subunit composition. Sucrose synthase isoform I (SuSyI) was composed of two 84 kDa subunits and two 86 kDa subunits. Sucrose synthase isoform II (SuSyII) was composed of four subunits of 86 kDa. The two isoforms also differed in their reactivity in response to varying pH conditions. The optimum pH for sucrose cleaving activity was observed at pH 6.0 and pH 6.5 for SuSyI and SuSyII, respectively. The optimum pH for sucrose synthesizing activity occurred at pH 7.5 and 7.0 for SuSyI and SuSyII respectively. The observed differences in subunit composition and reactivity at different pH values suggest that multiple isoforms of sucrose synthase may provide a mechanism to regulate sucrose metabolism in sugarbeet root by differential regulation of the two isoforms and modulation of their activity by changes in cellular pH.

Klotz, K.L., Finger, F.L. Sugarbeet root sucrose synthase isoforms differ in developmental expression, subunit composition and response to pH. American Society of Plant Biologists Annual Meeting. 2002. Abstr 753 p. 164-165.

Two sucrose synthase isoforms have been identified by activity stained isoelectric focused polyacrylamide electrophoresis in developing sugarbeet (Beta vulgaris L.) root. Sucrose synthase isoform I (SuSyI) was present from the early stages of development to maturity. Sucrose synthase isoform II (SuSyII) was evident only in the late stages of development as roots approached and achieved maturity. The two isoforms were partially purified by combination of ammonium sulfate fractionation, affinity chromatography and anion exchange chromatography. Characterization of the two isoforms revealed that SuSyI and SuSyII share similar kinetic properties and exhibit similar changes ia activity in reposnse to changes in temperature. The two isoforms differed, however, in subunit composition. SuSyI was composed of two 84 kDa subunits and two 86 kDa subunits. SuSyII was composed of four 86 kDa subunits. The two isoforms also differed in their response to pH conditions. SuSyI exhibited maximum sucrose cleaving activity at pH 6.0; SuSyII exhibited maximum sucrose cleaving activity at pH 6.5. The optimum pH for sucrose synthesizing activity occurred at pH 7.5 and pH 7.0 for SuSyI and SuSyII, respectively. At physiological pH values, the two isoforms differed substantially in their response to changes in pH in both the sucrose cleavage and sucrose synthesis reactions. The observed differences suggest that sucrose synthase activity in sugarbeet root may be regulated by differential regulation of expression of the two isoforms and modulation of their activity by changes in cellular pH.

Friesen, T.L., Weiland, J.J. Electrophoretic karyotype of cercospora beticola. Mycological Society of America Annual Meeting. 2002. Abstr. p. 39.

Cercospora beticola, causal agent of Cercospora leaf spot is one of the most widespread fungi that affects yield and quality of sugar beet, table beet and Swiss chard. Because the perfect stage of this filamentous fungus is not known it is not possible to carry out classical genetic approaches such as linkage analysis to determine genome size and chromosome number. In an initial characterization of the genome of C. beticola, an electrophoretic karyotype has been done using contour-clamped homogeneous electric field (CHEF) electrophoresis. At least five distinct chromosome sized bands have been resolved in the range of approximately 3.0 to 5.7 megabases. Three of these bands show a higher intensity indicating that multiple chromosomes of equal size may be migrating together. This information will be used as a first step toward a better understanding of the size and structure of the genome of Cercospora beticola..

Metzger, M.S., Weiland, J.J. Testing biological control and induced systemic resistance for the control of aphanomyces root rot of sugarbeet. American Phytopathological Society. 2002 Abstr. v. 92(6) S55.

Seedling damping off and chronic root rot of sugarbeet caused by <i>Aphanomyces cochlioides</i> has caused increasing losses to U.S. producers. Lack of effective control measures for Aphanomyces root rot prompted the initiation of a program aimed at the discovery of new, safe components for disease control. A biological control bacterium and a known inducer of systemic resistance were tested for their ability to control Aphanomyces root rot at two locations in the Red River Valley of the north central U.S. during the 2001 growing season. At both field locations, sugarbeet yield was increased where seed was treated with the bacterium <i>Burkholderia cepacia</i> AMMDR1. At one location, treatment with formulated harpin protein (Messenger^{TM}) also resulted in increased sugarbeet yield. Future testing will aid in determining new approaches to be implemented alone or in conjunction with current disease control measures to reduce losses caused by this serious pathogen of sugarbeet.

Metzger, M.S., Weiland, J.J. Field biocontrol of aphanomyces cochlioides. Abstracts of Joint Meeting of International Institute for Beet Research and the American Society Sugar Beet Technologists. 2003. Abstr. p. 53.

Seedling damping off and chronic root rot of sugarbeet caused by Aphanomyces cochlioides has caused increasing losses to U.S. producers. Lack of effective control measures for Aphanomyces root rot prompted the initiation of a program aimed at the discovery of new, safe components for disease control. A biological control bacterium and a known inducer of systemic resistance were tested for their ability to control Aphanomyces root rot at two locations in the Red River Valley of the north

central U.S. during the 2001 growing season. At both field locations, sugarbeet yield was increased where seed was treated with the bacterium Burkholderia cepacia AMMDR1. At one location, treatment with formulated harpin protein (MessengerTM) also resulted in increased sugarbeet yield. Tests in 2002 included an additional Pseudomonas biocontrol bacterium and treatments involving harpin in combination with standard fungicides for seedling disease control. Future studies will aid in determining new approaches to be implemented alone or in conjunction with current disease control measures to reduce losses caused by this serious pathogen of sugarbeet.

Weiland, J.J. Transformation of *Pythium aphanidermatum* to geneticin resistance. Current Genetics. 2003. v.42 p. 344-352.

Conditions for the production of protoplasts and gene transfer in Pythium aphanidermatum were investigated. Efficient protoplast generation was possible after culture of mycelium in potato dextrose broth followed by digestion with 0.5% (w/v) each of cellulase and b-D- glucanase. Plasmid pHAMT35N/SK encoding the nptII gene under control of the Ham34 promoter from the oomycete Bremia lactucae was used to define electroporation parameters for gene transfer. A square-wave electroporation pulse of 2500V/cm at 50 mF capacitance reproducibly produced transformants, albeit at low efficiency (0.1-0.4 transformants from ~105 regenerable protoplasts per microgram of DNA). Twenty seven independant transformants exhibited wild-type growth on potato dextrose agar amended with geneticin at 50 mg/ml, a concentration that near completely inhibited the growth of untransformed fungus. Southern blot analysis indicated that transforming DNA was integrated into the fungal genome as a tandem array of plasmid monomers. Co-electroporation of of pHAMT35N/SK with pEGFP encoding enhanced green fluorescent protein (EGFP) under the control of the immediate early promoter from the mammalian cytomegalovirus produced transient expression of blue-green fluorescence. Application of the technique to studies on the biochemical basis for pathogenesis in this agriculturally-important group of fungi are discussed.

Weiland, J.J. A survey for the prevalence and distribution of *Cercospora Beticola* tolerant to Triphenyltin hydroxide and resistant to thiophanate methyl in 2002. 2002 Sugarbeet Research and Extension Reports, Cooperative Extension Service, North Dakota State University. 2003. vol 33. p. 241-246.

Cercospora beticola populations in Minnesota and North Dakota were evaluated for resistance and tolerance to fungicides commonly used in the region. For the growing season of 2002, samples exhibiting tolerance to triphenyltin hydroxide ranges from 35-85% (0.2 ppm level) and 11-52% (1.0 ppm level). Samples exhibiting resistance to the benzimidazole fungicide thiophanate methyl tested at the 5 ppm level ranged from 40-76%. After declining in recent years, the number of samples surveyed in 2002 that exhibited resistance to thiophanate methyl increased in the southern

Minnesota growing area. Tolerance to the triazole fungicide tetraconazole increased in 2002 from 2001 level, ranging from 3-15% of the samples tested at the 2 ppm level and 0-11% of the samples tested at the 10 ppm level.

Weiland, J.J. Protease secretion in aphanomyces cochlioides. Abstracts of Joint Meeting of International Institute for Beet Research and the American Society Sugar Beet Technologists.. 2003. Abstr p. 65.

Protease activities have been implicated in the infection of fish and crayfish by Aphanomyces astaci, a pathogen of these host organisms. In an effort to characterize protease activities produced by the sugarbeet pathogen A. cochlioides, culture supernatants of this oomycete were tested for bulk enzyme activity and examined for protease isozyme complement. Bulk protease activity was readily detected using azocoll as a colorimetric substrate. At least 8 distinct isoforms of protease secreted by A. cochlioides were detected after electrophoretic fractionation in native polyacrylamide gels containing co-polymerized gelatin. A subset of the protease activities was sensitive to inhibitors of trypsin, including the proteinacious trypsin inhibitors from lima bean. Co-culture of sugarbeet seedlings in the presence of A. cochlioides and lima bean trypsin inhibitor resulted in increased seedling survival relative to control inoculations. The data suggest that protease activities secreted by A. cochlioides may be virulence determinants in the infection of sugarbeet by this pathogen.

Weiland, J.J., Friesen, T.L. Functional genomics of cercospora beticola. Abstracts of Joint Meeting of International Institute for Beet Research and the American Society Sugar Beet Technologists. 2003. Abstr. p. 56.

Cercospora leaf spot continues to be a damaging and costly disease to sugarbeet production, yet our understanding of Cercospora genetics and biology remains incomplete. Studies were carried out to better characterize the genome of C. beticola and to provide methods for genome manipulation. An electrophoretic karyotype of C. beticola isolate 98-23 revealed the presence of 7-8 chromosomes ranging from ~0.5 megabases to ~5.5 megabases in size, comparable to the size range for the related soybean pathogen, C. kikuchii. Southern blot analysis of total C. beticola genomic DNA with fungal telomere probes supported the chromosome number estimate. The genome size of C. beticola estimated from the study is ~26-28 Mb. A gene transfer technology useful for gene ablation in this haploid fungus, as well as for gene introduction and analysis, was developed using Agrobacterium tumefacies strain EHA105. To date, a library consisting of 57 independent C. beticola transformants have been generated using the technique. Mutants of C. beticola produced in this manner that are compromised for the ability to infect sugarbeet will be detected using leaf disc inoculation. Analysis of genes disrupted by the transforming DNA will lead to new information regarding the basis for the infection of sugarbeet by this pathogen.

Weiland, J.J., Lewellen, R.T., Friesen, T.L. Tagging of disease resistance genes in sugarbeet. Plant Animal & Microbe Genomes Conference. 2003. Abstr #W322. p. 69.

The characterization of genes that confer resistance to diseases important to sugarbeet production has been hampered by a lack of markers associated with these genes. In ongoing collaborative research, we have begun generating molecular genetic markers linked to various disease resistance genes for which segregating populations of sugarbeet have been produced. Using RAPD analysis applied to a population segregating for the Bm gene conditioning resistance to beet mosaic virus, candidate markers for this gene have been obtained. An update on the progress of using resistance gene candidates in the characterization of sugarbeet germplasm exhibiting resistance to various diseases will be presented. Emerging approaches for the study of sugarbeet genes involved in disease resistance also will be discussed.

Weiland J.J. Tracking DNA polymorphisms in field populations of aphanomyces cochlioides. Fungal Genetics Conference. 2003. Abstr #445. p. 143.

Root and seedling disease caused by Aphanomyces cochlioides are serious impediments to sugarbeet production in wet growing regions, yet information on the genetics and the inheritance of virulence in this organism is lacking. No race structure for A. cochlioides has been reported and several studies have revealed limited genetic diversity in this oomycete using DNA-based technologies. In the present study, application of random amplified polymorphic DNA (RAPD) analysis to single zoospore isolates obtained from sugarbeet fields in the U.S. identified 2 polymorphisms that assorted randomly within local populations; some field populations harbored only one polymorphic type. The data indicate that these polymorphisms are found in A. cochlioides isolates ranging from the northern Red River Valley of the U.S. to the historic regions of sugarbeet production in Texas. mplications of this result in the development of novel virulence and fungicide resistance in A. cochlioides are discussed.

POLYMERASE CHAIN REACTION (PCR)-BASED DETECTION OF *APHANOMYCES COCHLIOIDES* USING ACTIN GENE SEQUENCES.
Project 620

John J. Weiland

The polymerase chain reaction (PCR) is a DNA based technique for amplifying specific sequences from the genomes of organisms. PCR technology has impacted many fields of biology, including the area of disease diagnosis in both plants and animals. Diagnostics using the PCR are sensitive and highly discriminatory, since they target genome regions whose DNA sequences have diverged throughout evolution. PCR-based diagnostics also require little time for a result to be secured (within one to two days), making them attractive to high-throughput diagnostic laboratories. More recently, exquisite quantitation of pathogens has been made a reality by the added technology of "real-time" PCR. In FY2002, an MJR Opticon II Real Time PCR system was purchased by our research unit for such studies to be undertaken..

The interests in our laboratory include the development of novel diagnostic tools for disease-causing fungi in sugarbeet with a special emphasis on the highly destructive pathogen *Aphanomyces cochlioides*.. For this reason, we designed our PCR assay for the discrimination of sugarbeet fungal pathogens upon DNA sequences of the actin and ribosomal RNA (rRNA) genes. The rRNA genes of all organisms harbor sequences that permit that organism to be "fingerprinted" according to that gene sequence. This fingerprinting analysis was applied to Aphanomyces populations that were collected in the U.S. ranging from the northern Red River Valley to (now abandoned) sugarbeet growing regions of Texas. The analysis revealed that *Aphanomyces cochlioides* populations in the central states of the U.S. are genetically uniform. Using a parallel technique of random amplified polymorphic DNA (RAPD) analysis, limited genetic diversity was detected in a field near Buffalo Lake, MN. In investigations which focused on additional isolates of *A. cochlioides* from this region in 2001, the genetic diversity detected was found to be wide-spread throughout the sampled field (see 2001 Sugarbeet Research Report). In 2002, a specific DNA primer set was designed for the upper band that had been cloned previously. This primer set can now be used to identify just those isolates that are characterized by the larger 1.6 kb RAPD product (Figure 1). This "sequence tagged site" (STS) marker will permit more robust screening of isolates from sugarbeet fields for the presence of this DNA polymorphism. In experiments in 2003, potential differences in virulence to sugarbeet between "high-band" and "low-band" types will be examined in controlled inoculations of both seedlings and mature roots.

Also in 2002, a defined inoculation protocol for the generation of Aphanomyces black root disease in sugarbeet seedlings was developed. This followed the installation of 4 new Conviron growth chambers that permit exquisite environmental control during expermimentation. The procedure will be used in conjunction with a protocol for generating root rot in mature, greenhouse-grown beets for the evaluation of resistance levels in breeding germaplasm and hybrids. Application of real time PCR for the quantitative assessment of *A. cochlioides* levels in infected tissue will permit the

discrimination of sugarbeet possessing high, moderate, and low tolerance to the pathogen. Use of real-time PCR in the evaluation of alfalfa varieties with resistance to *Aphanomyces euteiches* has proven to be as accurate as visual rating (Quantifying *Aphanomyces euteiches* in Alfalfa with a Fluorescent Polymerase Chain Reaction Assay. G. J. Vandemark, B. M. Barker, and M. A. Gritsenko. 2002. Phytopathology 92:265-271).
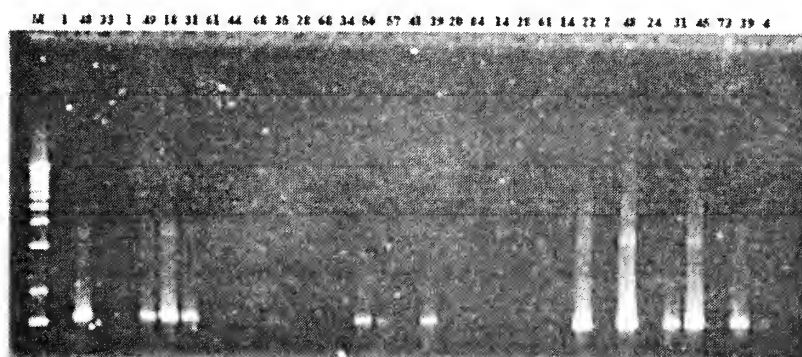
Figure 1.   Conversion of the 1.6kb RAPD product to an STS marker. Numbers across the lanes indicate A. cochlioides isolate number. Amplification of the 1.6kb product with specific primers. Distribution of marker in the population occurs at ~50%.

MECHANISMS OF RESISTANCE IN SUGARBEET TO FUNGAL AND BACTERIAL PATHOGENS
Project 621

John J. Weiland

Enzymes and enzyme inhibitors that accumulate in sugarbeet that is under pathogen stress often are associated with resisting pathogen invasion. Some of these activities are produced to strengthen natural barriers in the plant to pathogen invasion. Others are produces as an arsenal of compounds toxic to the pathogen or as inhibitors of phytotoxins produced by the pathogen. Identification of sugarbeet enzymes, and their corresponding genes, produced in defense against pathogens can further our understanding of the basis for disease resistance. Such knowledge can be used in the selection of germplasm with enhanced pathogen resistance. In addition, the cloning of the genes for defense-related enzymes and inhibitors can lead toward the production of genetically modified (engineered) germplasm for use in sugarbeet breeding programs.

Protease activity secreted in to the culture media by *A. cochlioides* is being investigated as a virulence component in the production of disease in sugarbeet. Proteases are produced in abundance by Aphanomyces species, including those that infect fish and crayfish. Previously in our lab, it was shown that a proteinase inhibitor from lima bean effectively inhibits a subset of the proteases that are seperable using gel electrophoresis. In 2002, we gained additional evidence that these proteases are indeed expressed in the Aphanomyces pathogen during invasion of the sugarbeet seedling (Figure 1). Moreover, we were able to show that the lima bean trypsin inhibitor, when added to axenic co-culture of sugarbeet seedlings and *A. cochlioides*, could reduce the rate of seedling root rot (Figure 2). The data to date suggest the protease secretion is important for high virulence of *A. cochioides* on sugarbeet, but other enzymes secreted by the pathogen are likely to play important roles as well. In 2003, extracts from the roots of sugarbeet with known tolerance to *A. cochlioides* will be tested for the presence of proteinase inhibitors in an effort to reveal the mechanisms behind root rot resistance in these varieties.

In 2002, secreted esterase by *C. beticola* was further characterized. Gel filtration and native polyacrylamide gel electrophoresis indicate that esterase activity is secreted as a complex that dissassociates during purification. Preparative isoelectric focussing is being used to obtain large amounts of partially purifed esterase in order to begin substrate specificity tests. Our hypothesis is that esterase works in conjunction with secreted toxins of *C. beticola*, such as cercosporin, in the damage of plant cell membranes. Leaf infiltration studies will be done with the esterase preparation in order to determine whether the activity may contribute to virulence of *C. beticola* on sugarbeet. Gene transfer to *C. beticola* will help unravel the role of esterase and other factors in the infection of sugarbeet by this pathogen. This will be done using a technique developed in our lab for the transfer of DNA to Cercospora using *Agrobacterium tumefacies* (Figure 3).

Future studies with *A. cochlioides* will focus on the role of observed protease secreted by the pathogen in pathogen virulence and the nature of the induced esterase in sugarbeet seedlings. Finally, further characterization of the polygalacturonase inhibitor protein (PGIP) genes cloned from various plant species (including *Beta webbiana*) will be done; a cDNA clone will be isolated from *B. webbiana* representing the genomic cloned already analyzed to date. The expression of PGIP gene homologues in sugarbeet seedlings and adult roots with known resistance to *A. cochlioides* will be examined in 2003.

Figure 1. Protease production by *A. cochlioides* in liquid culture (Ac) and in infected sugarbeet seedlings. Protease activity in healthy seedlings is presented as a control. Activities were separate on a 10% Non-denaturing SDS-PAG containing gelatin as a protease substrate.
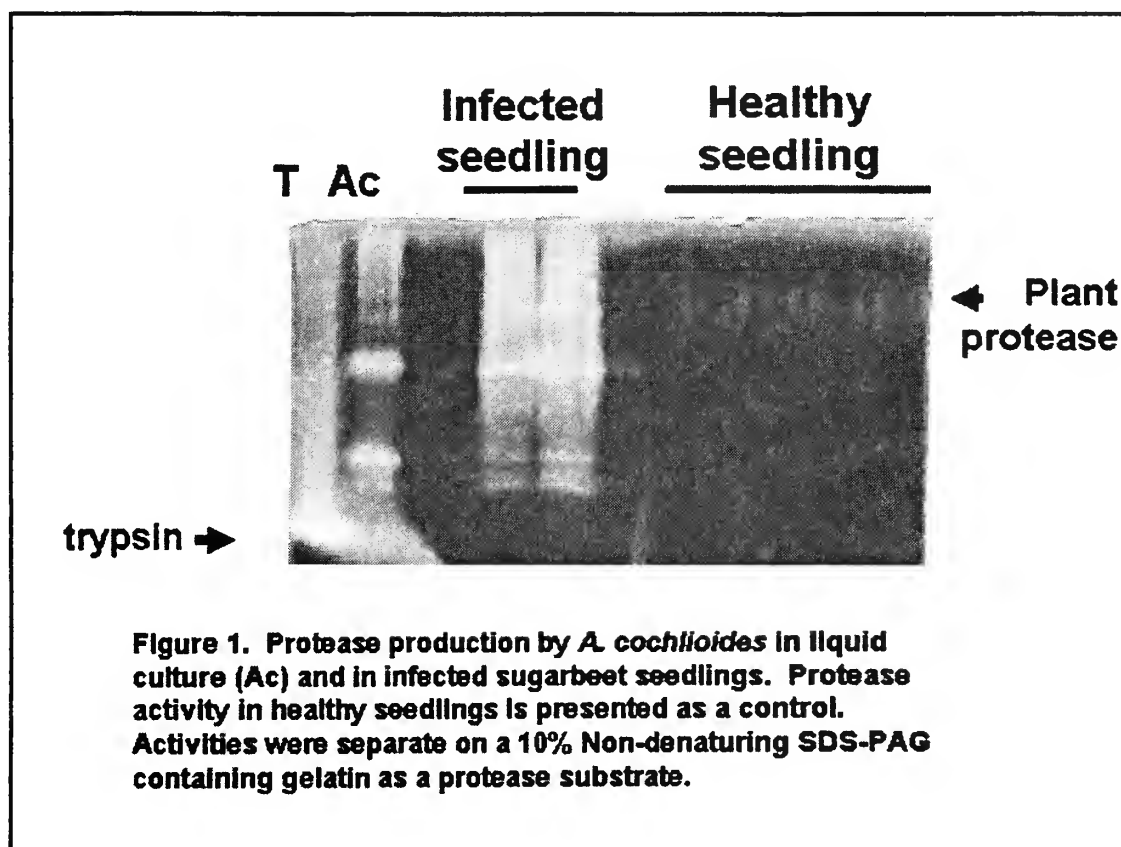
	day 0	day 7	day 14	rep
A.c. alone	10	2	0	1
	10	0	0	2
	9	2	1	3
A.c. + LB trypsin inhibitor	10	9	2	1
	10	10	8	2
	10	5	0	3

healthy seedling count

Figure 2. Decreasing the rate of seedling decline with lima bean trypsin inhibitor. Inoculum (100 zoospores/ml) was added to the seedlings prior to the addition of inhibitor at 10 ug/ml.

TAGGING OF GENES FOR DISEASE RESISTANCE IN SUGARBEET USING MOLECULAR GENETIC MARKERS
Project 622

John J. Weiland

Markers that tag regions of chromosomes that harbor genes contributing to disease resistance in sugarbeet can be of use in many aspects of research. Such landmarks on the genomic map can be used in marker-assisted selection in sugarbeet breeding programs. In addition the markers can provide information regarding the clustering or lack thereof regarding the distribution of resistance genes throughout the genome. Finally, chromosome markers can be integral tools in the identification of DNA clones that potentially harbor resistance gene sequences. Cloned resistance genes can be analysed for clues as to their mode of action and can be transferred between plant species using gene transfer technologies.

We have focused early efforts on the tagging of resistance to powdery mildew disease and to root knot nematode. Similar work has already been done in European laboratories the analysis of resistance to Cercospora leaf spot and Rhizomania diseases. Powdery mildew (*Erysiphe polygoni*) and root knot nematode (*Meloidogyne* spp) resistance in sugarbeet has recently been characterized by ARS colleagues in Salinas, CA. Both genes show promise for the genetic control of several races of the organisms causing these diseases. In collaboration with Drs. Robert Lewellen and Ming Yu, these resistance genes are being tagged using the random amplified polymorphism (RAPD) technique.

In 2002, a report detailing the tagging of resistance to root knot nematode in sugarbeet was accepted for publication and the sequence for the marker transferred to the public. Additionally, a sugarbeet population segregating for resistance to Beet Mosaic Virus (BMV) was rated for symptoms (Figure 1) and DNA markers were obtained with weak linkage to this gene (Figure 2). Additional markers for this gene will be forthcoming, with the intent of obtaining markers with greater linkage values.

The project also seeks to develop, in 2003, methods for evaluating a sugarbeet population segregating for resistance to Aphanomyces chronic root rot. With the addition to our facilities of state-of-the-art growth chamber facilities, the inheritance of resistance to both seedling phase and adult root phase Aphanomyces root rot will be examined in segregating populations. After characterization of the inheritance of resistance using this procedure, molecular marker tagging then will be applied to this population as well. As an added benefit, the inoculation and rating procedures produced from this work should be useful for screening germplasm for Aphanomyces resistance. Finally, in 2003, a root inoculation procedure for the initiaion of Cercospora leaf spot (CLS) will be tested for the ability to detect quantitative trait loci associated with resistance to *C. beticola* in a growth chamber setting. Preliminary results in our laboratory indicate that CLS can be produced in this manner and issues forth new concepts regarding the infection cycle of this important sugarbeet pathogen.

140 plants tot.; 111 resistant, 29 susceptible, $X^2 = 1.37$, $P = 0.242$
F2 population 1221-2-2 from R. T. Lewellen, USDA-ARS, Salinas, CA
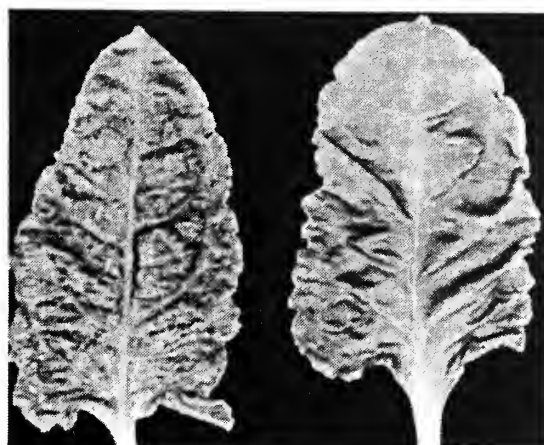
Without *Bm*　　　With *Bm*
resistance gene　　resistance gene

Figure 1　Inheritance of resistance to beet mosaic virus (BMV) in sugarbeet. Inoculations were carried on in a greenhouse at the USDA-ARS-Fargo laboratory and rated for disease at 18 days post-inoculation.

resistant　　　　susceptible

resistant　　susceptible
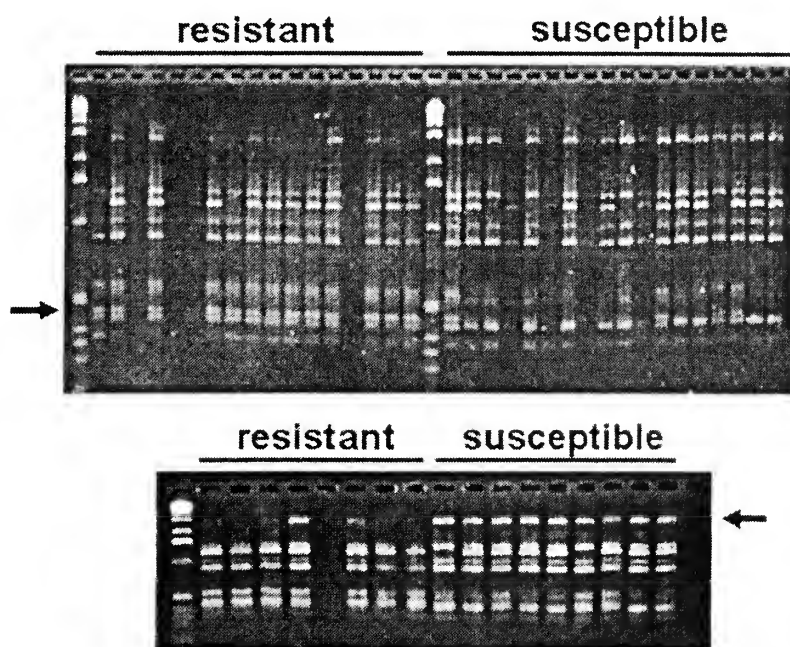
Figure 2　RAPD markers associated with resistance to BMV in sugarbeet. Both coupling and repulsion markers with respect to resistance were obtained.

IDENTIFICATION OF THE SUCROSE METABOLIZING ENZYMES RESPONSIBLE FOR SUCROSE LOSSES DURING SUGARBEET DEVELOPMENT AND STORAGE
Project 650

Karen Klotz

Introduction

Sucrose catabolism in sugarbeet root is a major factor controlling carbon partitioning to the root, root growth, sucrose accumulation during development and postharvest sucrose loss (Wyse, 1974; Giaquinta, 1979; Sung *et al.*, 1989; Berghall *et al.*, 1997; Klotz & Finger, 2002). Three enzyme families, the acid invertases, the alkaline invertases, and the sucrose synthases, are responsible for nearly all sucrose catabolism in sugarbeet root. The acid invertases catalyze the hydrolysis of sucrose to fructose and glucose, and occur as soluble and insoluble forms in the vacuole and cell wall, respectively. The alkaline invertases also catalyze the hydrolysis of sucrose to fructose and glucose, but are located in the cytoplasm and exhibit activity at higher pH values than the acid invertases. The sucrose synthases catalyze the conversion of sucrose to fructose and UDP-glucose, a metabolically activated form of glucose, and are localized to the cytoplasm.

The roles of the individual sucrolytic activities in carbon partitioning, root growth, and sucrose accumulation and degradation are largely unknown, although roles for sucrose synthase in carbon partitioning (Sung *et al.*, 1989), root growth (Klotz & Finger, 2002), and postharvest sucrose loss (Sakalo & Tyltu, 1997), and roles for acid invertase in sucrose accumulation (Giaquinta, 1979; Berghall *et al.*, 1997) and postharvest sucrose loss (Wyse, 1974; Berghall *et al.*, 1997) have been proposed. Understanding the individual roles of these enzymes and the factors that regulate their expression and activity, however, is key to understanding yield, sucrose accumulation and postharvest sucrose loss in sugarbeet root, and may provide insight into methods to increase the yield of extractable sucrose by alteration in cultural or storage practices, or by genetic selection or modification.

Results and Discussion

Sucrose synthase activity is closely associated with nonextractable dry matter accumulation.
The activities of the major sucrolytic enzymes were determined in three *Beta vulgaris* L. genotypes with differing capacities to accumulate mass and sucrose, and the relationships between these activities and the accumulation and partitioning of sucrose and dry matter were determined. The genotypes used were a low sucrose accumulating, high yield fodder beet variety (Monovigour, Danisco, Denmark), the low yield, high sucrose accumulating sugarbeet breeding line L19 (PI 590690), and the commercial sugarbeet hybrid VDH66156 (Van der Have, Netherlands) chosen to be intermediate in yield and sucrose content. The raw data from this study was reported in last year's progress report (Sugarbeet Research 2001 Report, pp. D13-D16). In the past year, this data was thoroughly analyzed for relationships between the major sucrolytic activities and physical and chemical parameters of the root.

Total sucrose synthase activity was positively associated with sugarbeet root dry matter accumulation, regardless of genotype or stage of development (Figure 1A). To better understand this relationship, total dry matter was divided into its two principal components, sucrose and

A
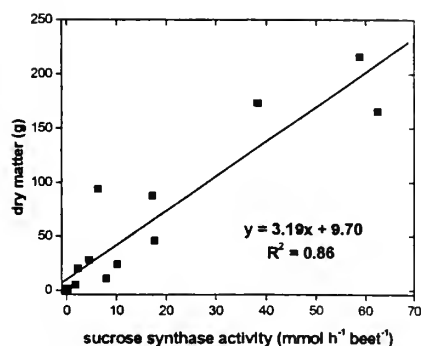
B
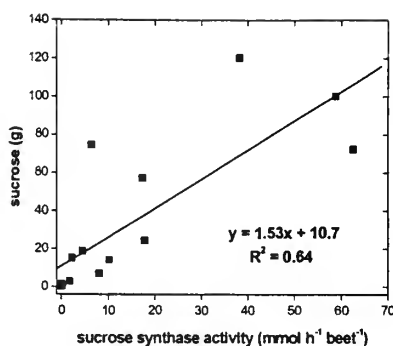
C
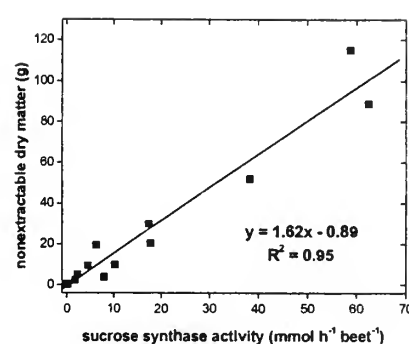
Figure 1: Relationship between sucrose synthase activity and (A) total dry matter, (B) accumulated sucrose, and (C) nonextractable dry matter in sugarbeet root. Measurements were made on three *Beta vulgaris* L. genotypes at five stages of development. Genotypes included the fodder beet variety "Monovigour," the commercial sugarbeet hybrid VDH66156, and the sugarbeet breeding line L19. Each genotype was sampled at 4, 6, 8, 12 and 16 weeks after sowing. Each data point is the mean of 10 replicates.

nonextractable dry matter, and these components were compared to total sucrose synthase activity of the root (Figure 1B & C). Nonextractable dry matter included all components of the cell not extracted with refluxing 80% ethanol and was primarily composed of cell wall materials. Sucrose synthase activity was closely associated with the accumulation of nonextractable dry matter (R^2 = 0.95), but not with sucrose accumulation (R^2 = 0.64). The positive relationship between sucrose synthase activity and nonextractable dry matter suggests a role for sucrose synthase in limiting or controlling cell wall biosynthesis by limiting substrate availability. The product of sucrose synthase activity, UDP-glucose, is the primary substrate for cell wall biosynthesis and a role for sucrose synthase in cell wall biosynthesis has been demonstrated in cotton (Amor *et al.*, 1995). By controlling the rate of cell wall biosynthesis, sucrose synthase may be a factor regulating the size, mass and, ultimately, yield of the sugarbeet crop.

No close association was observed between any of the sucrolytic activities and sucrose concentration or accumulation. Although other research groups have reported an inverse relationship between acid invertase activity and sugarbeet root sucrose content (Wyse, 1974; Giaquinta, 1979; Berghall *et al.*, 1997), no such relationship was observed in this research. The absence of a relationship questions the importance of acid invertase as a regulator of sugarbeet sucrose accumulation, but does not completely discount this theory since studies of the type reported here ignore tissue specificity of expression and cell compartmentalization.

Sucrose synthase activity increases during storage and in response to low temperatures. In conjunction with research described under Project 660, the response of the activities of the major sucrolytic enzymes to temperature and wounding during short-term storage were determined (Figure 2). Greenhouse grown roots (VDH66156) were hand harvested 16 to 18 weeks after planting, gently washed, and placed into storage at 10° or 1°C with or without prior wounding. Wounded roots were

A. Acid invertase activity at 10°C
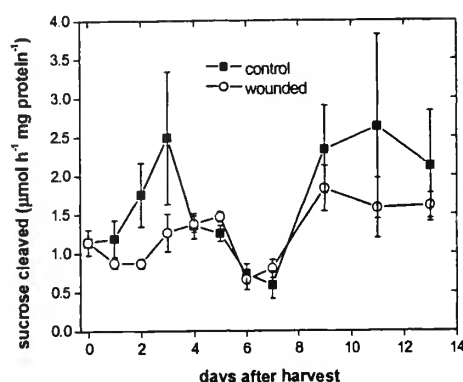
B. Acid invertase activity at 1°C
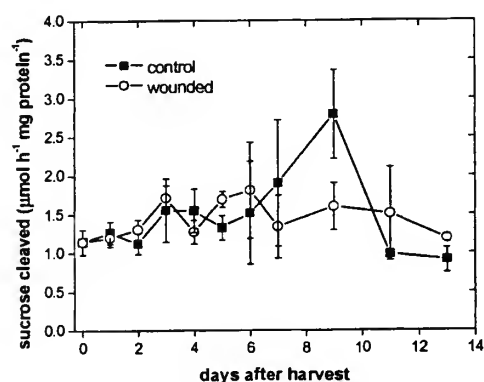
C. Alkaline invertase activity at 10°C
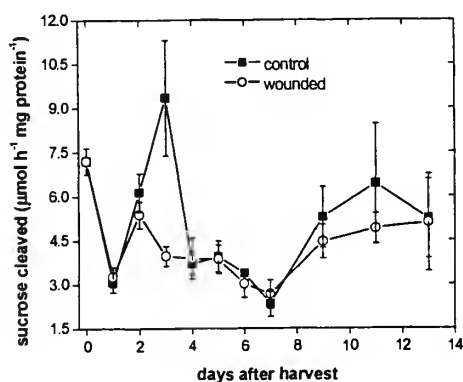
D. Alkaline invertase activity at 1°C
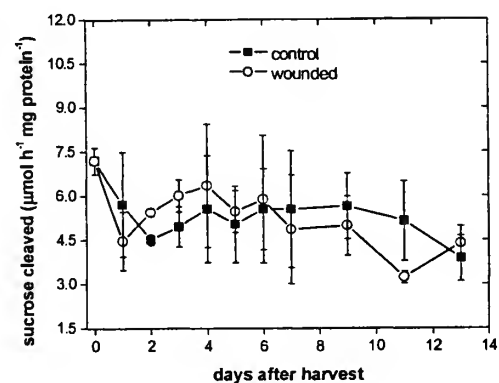
E. Sucrose synthase activity at 10°C
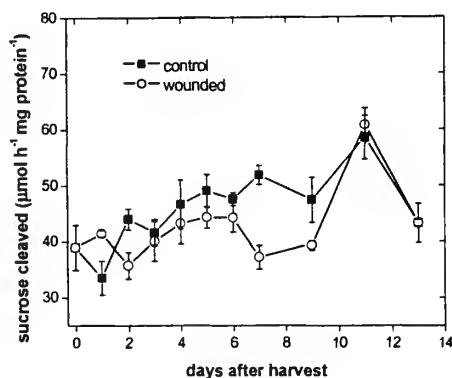
F. Sucrose synthase activity at 1°C
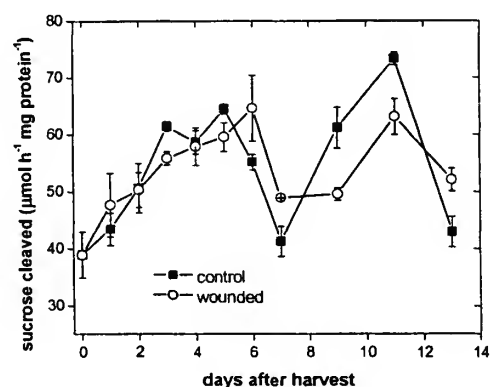
Figure 2: Changes in soluble acid invertase (A & B), alkaline invertase (C & D) and sucrose synthase (E & F) activities in response to wounding and storage temperature. Greenhouse grown roots were hand harvested 16 to 18 weeks after planting, washed and placed into storage at 10° (A, C & E) or 1°C (B, D, & F) for one to thirteen days. Half of the roots were severely bruised prior to storage by tumbling for 30 min in a pilot lab beet washer. Data are the mean of four replicates ± standard error. - ■ - unwounded control roots, - O- wounded roots.

delivered a severe bruise by tumbling for 30 minutes in a pilot lab beet washer. Tissue was sampled approximately 1 cm beneath the epidermis at the widest portion of the root.

Soluble acid invertase (Figures 2A & B) and alkaline invertase activities (Figures 2C &D) were relatively unchanged in response to wounding, storage temperature and duration in storage. Sucrose synthase activity, however, generally increased during storage and in response to low temperature (Figures 2E & F). No significant changes in soluble acid invertase and alkaline invertase activities were observed in roots stored at 1°C (Figures 2B & 2D). At 10°C, soluble acid invertase activity was unchanged in wounded roots, but exhibited two transient increases at 3 and 11 days after harvest in unwounded controls. Alkaline invertase activity in all roots stored at 10°C generally declined during the first seven days in storage, but rebounded to near initial values with additional time in storage, similar to results achieved in an earlier storage experiment (Klotz & Finger, 2001). Sucrose synthase activity generally increased during the first eleven days in storage with the increase in activity more notable at 1° than at 10°C (Figures 2E & F). A transient decline in sucrose synthase activity was noted for all roots at 1° and wounded roots at 10°C seven days after harvest, and all roots, regardless of storage temperature or extent of wounding, exhibited a decline in activity after thirteen days in storage that returned sucrose synthase activity to levels similar to that occurring in roots at time of harvest. Wounding did not increase the activity of any of the sucrolytic enzymes at either storage temperature during thirteen days in storage. This is in contrast to the results of Rosenkranz *et al.* (2001) who report an increase in soluble acid invertase activity in response to wounding.

Isolation of sucrose synthase genes. Research was begun to isolate sugarbeet root sucrose synthase genes. The isolation and characterization of sucrose synthase genes will aid in understanding the function and regulation of sucrose synthase isozymes and could be used for genetic screening of existing germplasms or genetic modification. Toward this goal, a cDNA library was constructed from greenhouse grown sugarbeet root (VDH66156) harvested ten weeks after planting. A sucrose synthase EST clone has been obtained from Dr. Mitch McGrath, USDA-ARS, East Lansing, MI. This clone will be characterized in the upcoming months and used to screen this library for sugarbeet root sucrose synthase genes.

Conclusions

➤ Total sucrose synthase activity of the root is positively associated with root nonextractable dry matter, which is primarily composed of cell wall materials. This relationship suggests a role for sucrose synthase in limiting cell wall biosynthesis. In such a way, sucrose synthase may have a role in controlling root size, mass and, ultimately, yield of the sugarbeet crop.

➤ No relationship between sucrose accumulation and any sucrolytic activity was observed. This questions the importance of soluble acid invertase as a regulator of sucrose content. It also suggests that the factors that regulate sucrose content in sugarbeet root are largely unknown.

➤ Sucrose synthase activity increases during short term storage and in response to low temperature. The increase in sucrose synthase activity may have implications for the sucrose loss that occurs in the first week of storage and during the cooling of sugarbeet roots to near freezing temperatures.

➤ Soluble acid invertase activity was present at low levels and was generally unaffected by wounding, temperature or duration of storage. The unchanging low activity of this enzyme observed in this and other postharvest studies conducted by this laboratory cause us to question literature reports that conclude that acid invertase is primarily responsible for postharvest sucrose loss.

➤ None of the major sucrolytic activities were induced by wounding in roots stored at 10° or 1°C. This was surprising since wound healing requires metabolic substrates and energy, and suggests that sucrolytic activities already present in the root are sufficient to meet the metabolic demands for wound healing or these metabolic demands are met through other catabolic pathways.

References

Amor, Y., Haigler, C., Johnson, S., Wainscott, M., Delmer, D. 1995. A membrane-associated form of sucrose synthase and its potential role in synthesis of cellulose and callose in plants. Proc. Natl. Acad. Sci., USA, 92:9353-9357.

Berghall, S., Briggs, S., Elsegood, S.E., Eronen, L., Kuusisto, J., et al. 1997. The role of sugar beet invertase and related enzymes during growth, storage and processing. Zuckerind., 122:520-530.

Giaquinta, R.L. 1979. Sucrose translocation and storage in the sugar beet. Plant Physiol., 63:828-832.

Klotz, K., Finger, F. 2001. Sucrose metabolism in postharvest sugarbeet roots: activities and properties of the major sucrolytic enzymes. 2000 Sugarbeet Res. Ext. Rep., Coop. Ext. Ser., ND State Univ., 38:147-149.

Klotz, K.L., Finger, F.L. 2002. Contribution of invertase and sucrose synthase isoforms to sucrose catabolism in developing sugarbeet roots. J. Sugar Beet Res., 39:1-24.

Rosenkranz, H., Vogel, R., Greiner, S., Rausch, T. 2001. In wounded sugar beet (Beta vulgaris L.) tap-root, hexose accumulation correlates with the induction of a vacuolar invertase isoform. J. Exp Bot., 52:2381-2385.

Sakalo, V., Tyltu, A. 1997. Enzymes of carbohydrate metabolism in sugar beet roots in the course of short-term storage under unfavorable conditions. Russ. J. Plant Physiol. 44:70-76.

Sung, S., Xu, D., Black, C. 1989. Identification of actively filling sucrose sinks. Plant Physiol., 89:1117-1121.

Wyse, R. 1974. Enzymes involved in the postharvest degradation of sucrose in Beta vulgaris L. root tissue. Plant Physiol., 53:507-508.

CHARACTERIZATION OF RESPIRATORY PROCESSES IN SUGARBEET ROOTS DURING POSTHARVEST STORAGE
Project 660

Karen L. Klotz and Marc D. Anderson

Introduction

Respiration is the oxidative process that converts glucose to carbon dioxide and water, providing substrates and energy for biochemical synthesis and maintenance of plant cells. In sugarbeet roots, sucrose is the primary source of the respiratory substrate, glucose, and it is estimated that 70% of the sucrose lost during postharvest storage under favorable conditions is used to fuel respiration (Wyse, 1973). Respiration is required to maintain healthy tissue during storage, heal wounds acquired during harvest and defend against storage pathogens. The actual respiratory requirements of sugarbeet roots, however, are unknown, although the identification of sugarbeet lines with reduced respiratory rates suggests that a reduction in postharvest respiration is possible (Theurer *et al.*, 1978; Wyse *et al.*, 1978). Respiration is influenced by many environmental and physiological conditions including storage temperature, oxygen and carbon dioxide concentrations, production conditions, injury, and other physiological stresses. The influence of these effectors on sugarbeet postharvest respiration is largely unexplored.

In sugarbeet, as in all plants, two respiratory pathways are operational, the cytochrome c oxidase (COX) pathway and the alternative oxidase (AOX) pathway. The COX pathway is the predominant respiratory pathway in nearly all plant tissues and organs and couples respiration to the production of chemical energy in the form of ATP. The AOX pathway is a minor contributor to total respiration in most plant tissues, and is generally considered to be energetically wasteful since it uncouples respiration from energy production, resulting in the generation of heat. Respiration through the AOX pathway can increase during periods of oxidative stress and is induced by wounding and chilling injury in some plant species (Moore *et al.*, 2002). The importance of the AOX pathway in sugarbeet roots and its induction by typical postharvest stresses is not known.

Research was initiated to characterize the respiratory processes responsible for postharvest sucrose loss and determine the effect of environmental and physiological conditions on postharvest sugarbeet root respiration. In these studies, sugarbeet root respiration and the contribution of COX and AOX pathways to total respiration were examined in different portions of the root and in response to wounding, storage temperature and duration in storage. The goal of this research was to gain fundamental knowledge of the factors that regulate and influence sugarbeet respiration. This information may potentially provide insight into methods to reduce postharvest respiratory sucrose loss.

Materials and Methods

Sugarbeets (VDH66156, Van der Have, Netherlands) were greenhouse grown, hand harvested 16 to 18 weeks after sowing, and gently hand washed prior to use. For storage studies, roots were wounded by tumbling in a pilot scale beet washer for 30 minutes and tissue samples for respiration

and mitochondria isolation were taken approximately 1 cm below the epidermis at the widest portion of the root. Respiration was measured as O_2 consumption at 25°C using an oxygen electrode (Moore & Whitehouse, 1997). Total respiration rate was measured as the difference in O_2 consumption of tissue before and after the addition of the respiratory pathway specific inhibitors, KCN and salicylhydroxamic acid (SHAM). Capacities of the COX and AOX pathways were determined with isolated mitochondria (Day & Wiskich, 1975; Vanlerberghe *et al.*, 2002). Capacity of a pathway was measured as the difference in O_2 consumption before and after the addition of an inhibitor specific for the pathway being measured after complete inhibition of the competing respiratory pathway.

Results

Respiration and respiratory pathway capacities in different regions of the root. Total respiration and the capacities of the COX and AOX pathways were examined in different areas of the sugarbeet root (Table 1). Tissue was sampled at the shoulder of the crown, 1 cm beneath the epidermis (crown internal tissue), at the widest portion of the root, 1 cm from the longitudinal center of the root (internal root tissue), and at the outermost 1 to 2 mm of the root at its widest portion (surface tissues). Total respiration was 8-fold greater in surface tissues and 1.5-fold greater in the internal tissue of the crown than in the internal tissue of the root. The internal tissues of the root and crown were similar in the capacities and the relative capacities of the two respiratory pathways, with the capacity of the COX pathway five to six-fold greater than the capacity of the AOX pathway. Surprisingly, the COX and AOX capacities were significantly lower in surface tissues, relative to the internal tissues of the crown and root, despite the higher rate of total respiration observed in surface tissues, suggesting that respiratory capacity does not limit or regulate respiration in sugarbeet roots. The relative capacity of the AOX pathway was greater in root surface tissues, perhaps in response to or to protect against environmental stresses that are more likely to be encountered at the root surface.

Table 1: Total respiration and capacities of the COX and AOX pathways in different regions of the root. Relative capacities of the COX and AOX pathways as a percent of the total respiratory capacity of the tissue are given in parentheses. Data are the mean ± standard error.

tissue	total respiration nmol O_2 min^{-1} g tissue^{-1}	COX capacity nmol O_2 min^{-1} mg protein^{-1} (%)	AOX capacity nmol O_2 min^{-1} mg protein^{-1} (%)
internal crown	13.3 ± 1.5	205 ± 19 (85.1 ± 1.1)	36.6 ± 5.4 (14.9 ± 1.1)
internal root	8.8 ± 1.3	196 ± 34 (84.7 ± 2.4)	33.9 ± 5.6 (15.3 ± 2.4)
surface	73.5 ± 8.1	73.3 ± 18.1 (57.7 ± 6.9)	68.6 ± 34.7 (42.3 ± 6.9)

Effect of wounding, storage temperature, and duration of storage on respiration and respiratory pathway capacities. The effects of wounding and storage temperature on total respiration and the absolute and the relative capacities of the COX and AOX pathways were determined by incubation of freshly harvested roots at 10° or 1°C for thirteen days with or without prior wounding. Respiration was elevated in wounded roots at 10°C (Figure 1A), but not at 1°C (Figure 1B).
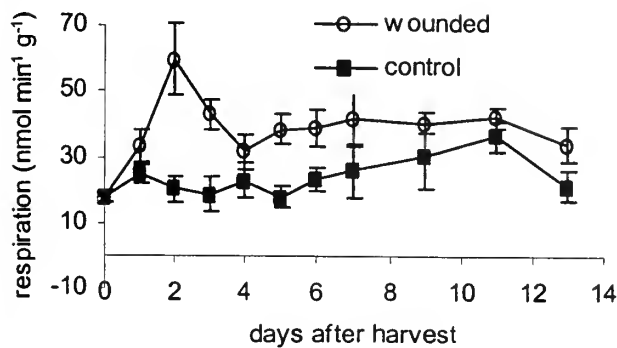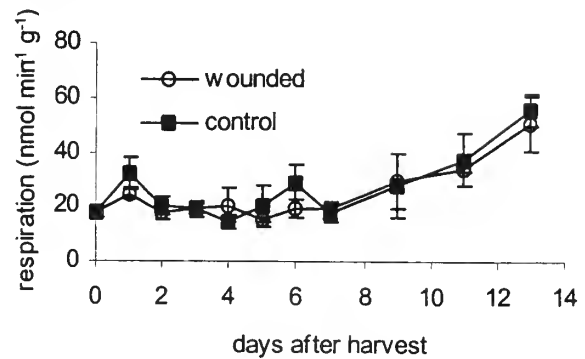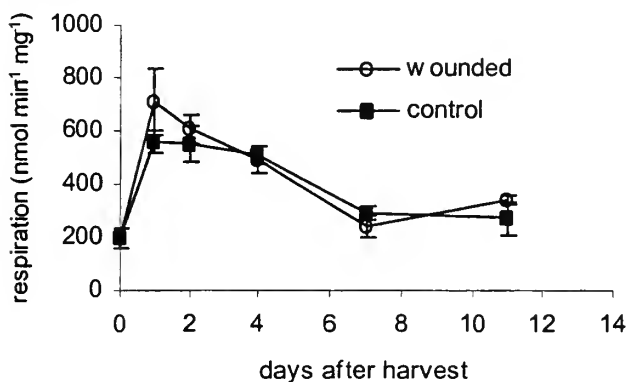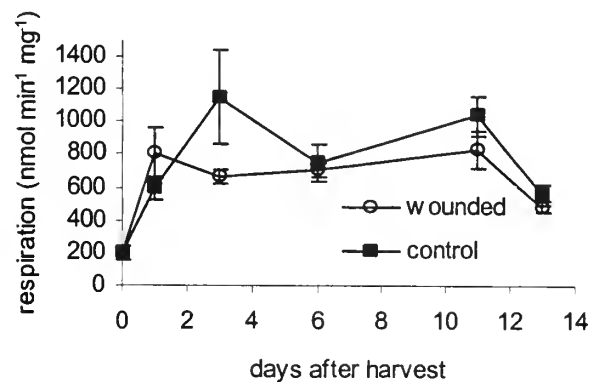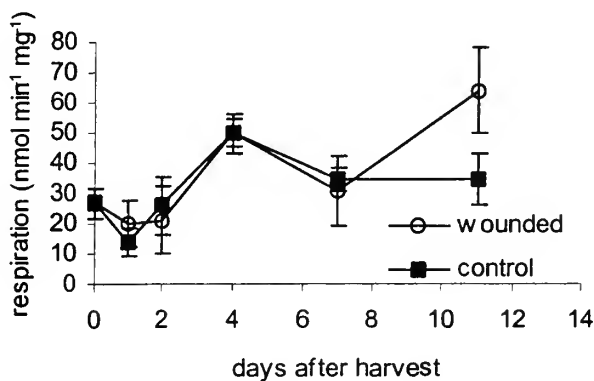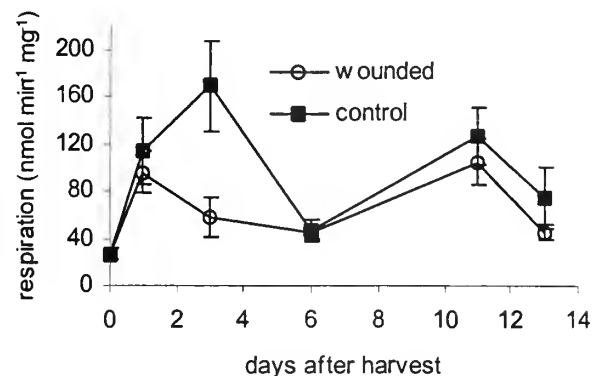
Figure 1: Total respiration and capacities of the COX and AOX pathways in sugarbeet roots stored for 13 days at 10° and 1°C with and without wounding. Control roots were gently hand harvested and placed into storage without further treatment. Wounded roots were severely bruised by tumbling in a pilot lab beet washer for 30 minutes immediately after harvest. Tissue was sampled approximately 1 cm below the epidermis at the widest portion of the root. Data are mean ± SE.

Maximum respiration of wounded roots at 10°C occurred two days after harvest. No significant changes in respiration occurred in wounded or control roots stored at 1°C for the first nine days in storage, although respiration increased with storage beyond nine days. The cause for this increased respiration at 1°C with prolonged storage is unknown. All roots, regardless of degree of wounding or storage temperature exhibited a three to four-fold increase in COX capacity after 24 hours in storage (Figure 1C and 1D). With subsequent storage, COX capacity declined at 10°C, but remained elevated at 1°C. No major differences in COX capacity were observed between wounded and unwounded control roots at either storage temperature. AOX capacity also increased in wounded and control roots at 10° and 1°C (Figure 1E and 1F). An increase in AOX capacity was evident one day after harvest in roots stored at 1°C, while an increase in AOX capacity was not evident until four days after harvest in roots stored at 10°C. Few differences in AOX capacity were noted between wounded and unwounded control roots at either storage temperature. The relative capacities of the two respiratory pathways exhibited only minor alterations in response to temperature, wounding or duration in storage (Table 2). A transient increase in the relative capacity of the COX pathway occurred during the first two days in storage at 10°C, and six days after harvest in roots stored at 1°C. No elevation in the relative capacity of the AOX pathway was observed at either storage temperature.

Conclusions

➤ Respiration is six to eight-fold greater at the root surface than in the internal tissues of the root and crown.

➤ The capacity of cytochrome c oxidase pathway is greater than the capacity of the alternative oxidase pathway in all tissues examined. Cytochrome c oxidase is responsible for 85% of total respiratory capacity in the internal tissues of the root and crown and 58% of total respiratory capacity at the root surface.

➤ Wound induced increases in respiration were observed at 10°, but not at 1°C.

➤ Respiration increased with prolonged storage at 1°C. The cause for the elevation is respiration in roots stored for more than nine days at 1°C is unknown.

➤ No relationship between respiration rate and total respiratory capacity, cytochrome c oxidase capacity or alternative oxidase capacity was observed in any study, suggesting that respiratory capacity does not limit or regulate respiration in sugarbeet roots. Future research will examine whether respiration is regulated by substrate availability or product inhibition.

➤ The relative capacities of the COX and AOX pathways were mostly unchanged during short term storage, regardless of wounding or storage temperature, with the COX pathway responsible for the majority of root respiratory capacity. The data suggest that the AOX respiratory pathway is not significantly induced in sugarbeet root in response to harvest, cold temperature, or wounding.

Table 2: Relative COX and AOX capacities of roots stored at 10° and 1°C with or without wounding. Capacity is expressed at the percentage of total respiratory capacity. n.d., not done.

days after harvest	Relative COX capacity (% of total)				Relative AOX capacity (% of total)			
	10° C		1° C		10° C		1° C	
	wounded	control	wounded	control	wounded	control	wounded	control
0	88.1	88.1	88.1	88.1	11.9	11.9	11.9	11.9
1	97.4	97.6	88.1	84.0	2.6	2.4	11.9	16.0
2	96.2	95.1	n.d.	n.d.	3.8	4.9	n.d.	n.d.
3	n.d.	n.d.	92.5	87.1	n.d.	n.d.	7.5	12.9
4	90.7	91.1	n.d.	n.d.	9.3	8.9	n.d.	n.d.
6	n.d.	n.d.	94.0	94.2	n.d.	n.d.	6.0	5.8
7	89.6	89.3	n.d.	n.d.	10.4	10.7	n.d.	n.d.
11	84.7	87.9	90.8	90.5	15.3	12.2	9.2	9.5
13	n.d.	n.d	91.6	88.5	n.d.	n.d.	8.4	11.5

References

Day, D.A., Wiskich, J.T. 1975. Isolation and properties of outer membrane of plant mitochondria. Arch. Biochem. Biophys., 171:117-123.

Moore, A.L., Albury, M.S., Crichton, P.G., Affourtit, C. 2002. Function of the alternative oxidase: is it still a scavenger? Trends Plant Sci., 7:478-481.

Moore, A.L., Whitehouse, D.G. 1997. Isolation and purification of functionally intact mitochondria and chloroplasts from plant cells. p. 243-270. *In*: Graham, J.M., Rickwood, D. (eds.), Subcellular fractionation: a practical approach. IRL Press, Oxford, UK.

Theurer, J.C., Wyse, R.E., Doney, D.L. 1978. Root storage respiration rate in a diallel cross of sugarbeet. Crop Sci., 18:109-111.

Vanlerberghe, G.C., Robson, C.A., Yip, J.Y.H. 2002. Induction of mitochondrial alternative oxidase in response to a cell signal pathway down-regulating the cytochrome pathway prevents programmed cell death. Plant Physiol., 129:1829-1842.

Wyse, R.E. 1973. Postharvest losses of sucrose in sugarbeets. Proc. Beet Sugar Devel. Found. Conf. on Sugarbeet Storage. Beet Sugar Devel. Found., Denver, CO.

Wyse, R.E., Theurer, J.C., Doney, D.L. 1978. Genetic variability in post-harvest respiration rates of sugarbeet roots. Crop Sci., 18: 264-266.

SUGAR BEET RESEARCH

2001 REPORT

Section D

Sugarbeet and Bean Research Unit
Agricultural Research Service - USDA
East Lansing, Michigan

Dr. J. M. McGrath, Sugarbeet Geneticist

CONTENTS

* **Papers submitted for 2003 ASSBT Proceedings**

Agronomic Evaluation of Germplasm in One and Two Row Plots

J. Mitchell McGrath, Tim M. Duckert, and Teresa Koppin

USDA – Agricultural Research Service, East Lansing, MI

The agronomic tests 02BB01 (one row) and 02BB02 (two row) were planted April 16, 2002 in a 4 replication, randomized complete block design, North of Swan Creek Rd. Plot length was 27 feet in both one- and two-row plots. The previous crop was soybeans. The ground was fall chisel plowed followed by frost tillage in the early spring. All tests were treated pre-emergence with 5.6 pt/ac of Pyramin and 3 pt/ac of Nortron after planting. Nitrogen fertilizer was side-dressed at the rate of 120 lbs/ac. Mechanical thinning was performed June 7 and hand thinning was completed on June 10, at an average spacing of 6 inches between plants. Both tests were sprayed four times for Cercospora leaf spot control following recommended spray rotations. Both tests were conducted using PAT treated seed from 12 commercial lines from the Sugarbeet Advancement trials. All other seed was polished, cleaned and untreated. Data for stand counts and plot weights were taken, and no sucrose information was taken. The two-row test was harvested October 7 with the B&B research harvester and the one row test was harvested one week later, on October 15, with the USDA one row research harvester. Harvest plot length for both was 24.5 feet. Plots were shortened to remove alley border row effects.

This aim of this test, in part, was to provide information on the use of the new USDA one row research harvester for gathering agronomic data, with the eventual aim to develop a method to obtain sucrose data on the harvester as a means of selecting plant roots for further germplasm enhancement. Twenty entries were in common between one- and two-row tests for purposes of comparison. In general, plot weights were greater using the new one-row harvester compared with the two-row harvester, however the variability was also higher, and adjustments will be necessary. Some variability invariably arose from different inter-row competition effects in the one and two row plots. A greater number of accessions were tested in the one row plots for evaluation (Table 1). Some entries had poor stands. Entries 1 to 12 were from stored accessions dating prior to 1986 whose seed was increased in the same crossing plot and harvested as half-sib families. Entries 13 to 20 and 40 were the series of smooth-root germplasm releases and selections from the East Lansing program. Entries 22 to 30 were commercial entries from the Sugarbeet Advancement trials, and entries 31 to 39 were USDA-ARS Ft. Collins, CO Rhizoctonia resistance germplasm releases.

The other aim of this test was to evaluate materials for incorporation into new germplasm releases. Previous years agronomic trials at the Bean and Beet Farm have focused nearly exclusively on developing high sucrose, smooth root (HS-SR) germplasm. These activities have been successful, and disease resistance in the lines for Eastern growing conditions is generally good with the exception of Rhizoctonia resistance. USDA-ARS Ft. Collins Rhizoctonia resistant releases were evaluated for their potential role as donors of this trait to the HS-SR future releases, and selections from within the existing SR releases (RHIZOC '01 MIX) may show improved performance. Additional accessions with high vigor after 17 years in suboptimal storage (01B0xx) were increased in 2001, and yield was evaluated here, with some showing potential as donors for increased dry matter accumulation. 95HS2 and 96N7-00 were evaluated for potential release, and both showed high sucrose percentage in previous years and 96N7-00 was selected for acceptable agronomic performance under low nitrogen fertilizer application.

A unique set of 11 F3 families with potential Aphanomyces seedling resistance derived from PI540625 were tested in a seedling disease nursery north of the pond at the Bean and Beet Farm (Table 2). Agronomic performance was low as expected, however these lines were deep-rooted at harvest, suggesting a lower incidence of tip rot relative to frequently sprangled commercial hybrids and other germplasm.

Table 1: Average of four replicate plots for stand count and harvest data for agronomic tests 02BB01 and 02BB02. DAP = days after planting, nd = not determined.

Entry No.	Entry Name	Stand Count 13DAP 1 row	26DAP 1 row	39DAP 1 row	13 DAP 2 row	24 DAP 2 row	35 DAP 2 row	Yield Tons/acre 1 row	Yield Tons/acre 2 row
1	95HS2	68.8	183.8	225.8	nd	nd	nd	27.13	nd
2	96N7-00	100.0	161.3	224.3	nd	nd	nd	24.72	nd
3	01B001	60.0	92.5	117.0	nd	nd	nd	26.79	nd
4	01B002	48.8	107.5	120.8	nd	nd	nd	26.84	nd
5	01B005	45.0	108.3	112.3	nd	nd	nd	31.11	nd
6	01B006	20.0	87.5	100.8	nd	nd	nd	29.89	nd
7	01B007	68.8	112.5	124.8	nd	nd	nd	33.00	nd
8	01B009	66.3	116.3	141.8	nd	nd	nd	37.57	nd
9	01B010	51.3	102.5	107.0	nd	nd	nd	31.32	nd
10	01B011	53.8	93.8	104.0	nd	nd	nd	34.62	nd
11	01B012	38.8	108.8	114.3	nd	nd	nd	31.19	nd
12	01B013	62.5	118.8	127.0	nd	nd	nd	30.45	nd
13	SR80	67.5	113.8	165.8	72.5	122.5	155.3	27.78	30.53
14	SR87	96.3	108.8	95.0	112.5	133.8	177.5	33.97	32.10
15	SR93	70.0	101.3	105.8	68.8	135.0	144.3	34.94	33.01
16	SR94	106.3	90.0	98.5	107.5	91.3	179.8	33.47	29.05
17	SR95	81.3	120.0	126.5	96.3	126.3	175.3	27.28	28.20
18	SR96	86.3	110.0	119.8	103.8	95.0	164.5	29.55	30.10
19	SR97	52.5	67.5	68.3	65.0	95.0	114.0	30.08	26.29
20	EL0204	91.3	106.3	105.0	57.5	85.0	98.8	31.17	28.20
21	USH20	32.5	28.8	31.0	nd	nd	nd	30.46	nd
22	C1353	51.3	126.3	168.5	61.3	101.3	106.5	31.68	30.10
23	E33	76.3	81.3	89.5	78.8	103.8	136.5	29.97	26.44
24	B5451	58.8	23.8	23.0	52.5	96.3	98.0	39.15	32.82
25	E38	51.3	123.8	143.3	70.0	113.8	123.0	32.81	29.77
26	B5172	18.8	113.8	130.8	17.5	56.3	61.0	31.55	30.67
27	C913	32.5	160.0	223.5	50.0	92.5	108.8	32.03	26.20
28	SPARTAN	40.0	125.0	139.5	52.5	93.8	116.3	31.70	26.10
29	B5736	46.3	173.8	187.0	56.3	78.8	94.5	35.04	31.39
30	RH5	72.5	150.0	185.0	72.5	110.0	126.0	30.43	29.10
31	E17	57.5	153.8	165.0	36.3	105.0	119.5	34.18	31.20
32	C963	23.8	126.3	135.8	30.0	63.8	76.3	30.94	32.25
33	PROMPT	61.3	113.8	109.3	76.3	105.0	107.5	35.00	29.67
34	FC722-1	8.8	88.8	88.8	nd	nd	nd	6.27	nd
35	FC724-1	62.5	101.3	112.0	nd	nd	nd	18.18	nd
36	FC720-1	31.3	115.0	127.8	nd	nd	nd	15.58	nd
37	FC722-1 cms	5.5	93.8	104.3	nd	nd	nd	2.63	nd
38	FC710 (4X)	47.5	110.0	115.5	nd	nd	nd	23.74	nd
39	FC710 (4X)	57.5	62.5	60.0	nd	nd	nd	21.49	nd
40	RHIZOC '01 MIX	32.5	107.5	115.5	nd	nd	nd	35.21	nd
Mean		55.1	109.7	124.0	66.9	100.2	124.2	29.0	29.7
Std. Deviation		23.5	31.9	44.1	24.4	20.1	32.6	7.4	2.2
F Value		6.8	5.8	6.8	31.9	6.0	73.0	12.4	2.5
CV%		31.5	21.9	24.0	18.8	23.7	8.9	14.3	13.5

Table 2: Stand count and harvest data for three replicate disease nursery test 02BB03. DAP = days after planting.

Entry No.	Entry Name	13DAP 1 row	26DAP 1 row	39DAP 1 row	Tons/acre 1 row
1	Y03-384-139	3.7	24.3	30.7	9.98
2	Y03-384-127	17.0	26.0	35.3	13.49
3	Y03-384-126	22.7	50.3	48.0	4.51
4	Y03-384-109B	2.3	4.3	9.0	2.84
5	Y03-384-099	3.7	42.3	65.3	4.90
6	Y03-384-083	0.3	12.3	27.3	5.59
7	Y03-384-070	0.0	12.0	19.0	5.61
8	Y03-384-060	2.0	25.0	29.7	7.01
9	Y03-384-051	1.7	19.3	37.0	5.54
10	Y03-384-017	0.3	2.7	4.0	1.52
11	Y03-384-018	0.0	2.7	3.0	2.24
12	01B001	41.7	73.3	93.0	16.94
13	01B002	44.7	93.3	94.3	18.87
14	01B005	29.3	70.0	92.3	17.65
15	01B006	18.0	61.7	72.7	16.61
16	01B007	32.0	78.3	80.3	24.00
17	01B009	42.7	91.7	93.3	22.53
18	01B010	36.0	75.0	92.0	14.30
19	01B011	16.0	62.7	71.7	18.03
20	01B012	21.3	80.0	89.0	21.59
21	01B013	32.0	75.0	94.7	20.75
22	SR80	43.3	64.0	84.3	27.05
23	SR87	80.0	63.3	69.3	19.47
24	SR93	54.0	75.0	80.3	15.04
25	SR94	54.3	63.3	77.0	20.45
26	SR95	76.7	96.7	96.7	19.94
27	SR96	74.7	43.0	51.3	20.22
28	SR97	39.7	76.7	83.0	17.86
29	EL0204	66.7	75.0	85.0	20.47
30	USH20	38.7	71.7	77.7	16.36
31	C1353	29.7	86.7	94.3	18.69
32	E33	34.7	71.7	79.7	8.69
33	B5451	33.3	53.3	57.7	21.97
34	E38	43.3	74.0	84.0	20.12
35	B5172	12.7	15.0	15.7	16.97
36	C913	36.0	85.0	93.7	19.61
37	SPARTAN	28.0	82.7	101.0	19.39
38	B5736	35.3	105.0	113.7	14.07
39	RH5	38.0	76.3	93.3	17.86
40	E17	19.3	76.7	85.0	16.08
41	C963	16.0	63.0	85.7	22.81
42	PROMPT	34.0	150.0	186.7	23.43
43	98B040-73ms	3.3	108.3	120.3	14.55
44	USH20	50.0	108.3	118.7	18.39
45	ACH185	52.0	101.7	145.7	15.47
46	00J12-01	49.3	93.3	125.0	17.45
Mean		30.7	64.4	75.8	15.6
Std. Deviation		21.6	32.5	37.3	6.5
F Value		4.9	6.5	7.3	5.6
CV%		55.1	34.5	31.7	31.0

Seed Increases in Michigan

J. Mitchell McGrath, Tim M. Duckert, and Teresa Koppin

USDA – Agricultural Research Service, East Lansing, MI

On June 14, 2001 field trial 01EL39 was planted on campus, primarily as a test for new seed planting equipment. Sixteen rows (0.3 acres) of a F_2 Smooth Root Composite (WC92408, polished and sized over 5 mm in diameter) were planted with an Almaco modified John Deere 7200 4-row belt cone research planter. The plot was planted in 28" rows and cared for with normal agronomic practices. Plants were thinned to 6" spacing at eight weeks of age. The performance of the new equipment on properly sized and cleaned polished beet seed was deemed excellent.

Typical Michigan winters can be harsh on over wintering beets in the field, and seed production in Michigan is not normally attempted due to beet mortality. Since this field was in excellent shape going into the winter, and since further intercrossing of this F_2 composite population may further recombine desirable traits such as yield, sucrose, monogermity, and cold tolerance, the field was over-wintered in 2001. Root diameters were in a range of 1" to 4".

Winter was relatively mild with a steady snow cover during the coldest periods, except during March. An estimated 60% of the roots survived to early spring. A more precise evaluation was made after the plants began to bolt in late May. Most survivors from the winter months were smaller sized beets (< 1" diameter). Nitrogen was applied to the 16 rows (60 lbs N/ac) on April 18, 2002, as well as Betamix (3 pt/ac) to control fall-germinated weeds.

Seed harvest began July 22, 2002 with eight rows manually cut and placed on the ground to dry for threshing. Three days later, plants were manually threshed with assistance of a Hege 140 plot harvester. This process worked well however there was an enormous amount of seed shatter. The remaining eight rows were left standing so that their stems would dry and direct harvesting could be attempted. Two weeks later on August 9, the Hege 140 combine was used to harvest two rows per pass. This method was more labor efficient however less seed was collected (Table 1) because the extra drying period caused more seed to shed naturally. A total of 332 lbs of seed was collected off this trial. Some plants had monogerm seed and 18 of these plants were harvested separately.

Table 1: Harvest data collected from over wintered seed increase. Yield is pounds of seed harvested from 8 rows by two different methods and timings.

Method of harvest	Yield of raw seed (pounds)
Manual cutting July 22 and dry down 3 days	188
Direct cut machine harvest August 9	142
Monogerm seed hand harvest	1.8

Seed production, specifically for breeding improved populations, can be accomplished in Michigan. Large plot seed increases are currently done in Oregon. Inter-pollinating advanced breeding materials for population improvement, such as the early generation F_2 planted here, is an important genetic resource for continued selection for improved germplasm. Typical seed increases in the greenhouse result in limited seed yield from a small number of parents.

Field multiplication allows more plants to contribute to the seed, greater opportunity to select desirable plant forms (high seed yield, strong seed stalks), and increased chances of desired recombination of characters present in some but not all parents in the founding population. Characterization of the over 10,000 seedlots stored at East Lansing, many under sub-optimal storage conditions, will require regeneration of promising germplasm for proper agronomic evaluations. Expanding seed multiplication efforts to include field increases will help reduce the time for germplasm evaluation and potential release.

Selection for Low Temperature Stress Germination

Azeza Bughrara, R. Scott Shaw and J. Mitchell McGrath
Michigan State University and USDA – Agricultural Research Service, East Lansing, MI

Growers would like to plant as early as possible, while the ground is cold, in order maximize the length of the growing season. Temperature is one of the three important conditions for germination and emergence (the others being moisture and impedance, such as hard-seed and crusting). Varieties differ in emergence, but selection for emergence at colder temperatures, particularly under stress, is not routinely practiced. Analyses of stress germination at the molecular level have been facilitated by a novel liquid germination assay. This assay is flexible and allows conditions of germination to be varied to include different types of stress as well as their combinations. To date, molecular studies have relied on imposed chemical stress (e.g. salt, mannitol, oxalic acid), but only at room temperature. Water germination at low temperature on a series of germplasm lines was tested here.

Experiments were conducted to begin to examine heritability of low temperature germination. Fifty seeds from each of 10 entries (Table 1) were incubated in water at 5 C with shaking and examined daily for radicle protrusion from seed. Germinated seed was recorded and planted to peat pots for seed multiplication. Results showed differences between entries, with obsolete commercial hybrids showing highest germination (e.g. US H20 & ACH185), overall and within 10 days of immersion, with the exception of SR96. Genetic variability for low temperature germination, if it exists, will allow breeding of hybrids suited for early planting.

Table 1: Germination of 10 germplasm lines in water at 5 degrees Celsius.

	10 days	25 days	29 days	32 days	35 days	39 days	Total	% Germ
ACH185	3	0	0	13	12	0	28	56.0
USH20	3	0	10	0	14	0	27	54.0
SR96	4	10	0	0	12	0	26	52.0
SR93	1	6	0	7	0	0	14	28.0
EL0204	0	0	0	7	6	0	13	26.0
SR80	0	0	12	0	0	0	12	24.0
SR95	0	0	0	0	11	0	11	22.0
SR87	0	0	0	0	9	0	9	18.0
SR97	0	0	0	8	0	0	8	16.0
SR94	0	0	0	0	0	7	7	14.0
sum	11.0	16.0	22.0	35.0	64.0	7.0	155.0	
average	1.1	1.6	2.2	3.5	6.4	0.7	15.5	31.0
std dev	1.6	3.5	4.7	4.8	5.9	2.2	8.2	16.5

Real-time Sucrose and Yield Assisted Selection and Breeding
Tim M. Duckert and J. Mitchell McGrath
USDA-ARS

Sugarbeet breeding is a labor intensive and long-term process. Yearly evaluation of many breeding populations is necessary in order to find better combinations of existing characters, such as disease resistance, harvestability, impurities, sugar concentration, and sugar yield, and fix these combinations in improved germplasm populations. Genetic segregation in breeding populations is expected, and selection for improved agronomic performance based on population statistics necessarily averages high and low agronomic performance from individuals within the populations.

Over the past few years at East Lansing, the largest labor requirements have occurred during harvest. Beets are lifted with a harvester fitted with a scale to determine plot weight, and a sub-sample of the plot is bagged, loaded onto a trailer, and hauled to a processing station. Plot samples are run through a large gang saw, and brei is collected, squeezed, and frozen for chemical analyses at the Michigan Sugar factory laboratory. Results are available within two to eight weeks depending on factory schedules, and results of agronomic evaluations influence breeding decisions. The assistance of Michigan Sugar in this process is essential and gratefully acknowledged. A disadvantage of this system is that most beets harvested are consumed for sucrose analyses and few of the beets are available for further breeding, selection, or genetic analyses. Further, agronomic analyses are limited to the number of breeding lines that can be accommodated by available labor and other resources.

We have been developing a harvesting platform that may overcome some of these limitations, and help to expand the number of lines that can be tested in any given year under a wider range of agronomic conditions (e.g. disease nurseries). Such a need is evident from continuing discussions with other breeding programs. In 1999, concepts for a harvester were developed, and during the winter of 2001 / 2002 a prototype harvester was built at the Michigan State University Crops Barn as a proof of concept. Design elements included accommodations for transport between research locations, modular elements adaptable to future technology and research needs, safety and ergonomic needs of the fewer number of personnel available, and modern technology for lifting, cleaning and processing the beets. The new harvester was used during the 2002 field harvest, and is currently complete with the exception of chemical analyses instrumentation. Chemical analyses will be included in 2003, assuming availability of resources. This report lists the components of the prototype harvester. Suggestions for design modifications would be welcomed.

A design was conceived and a scale model built the summer of 2001, and a prototype built in 2002 (Figure 1). Many discussions took place to determine the best possible means to reach the goals in mind. Much of the project was drawn out on paper since computer aided design (CAD) skills were not in hand. Many years of design, fabrication and equipment handling experience were drawn upon to design each individual component as well as the frame to meet current and future requirements, ease of serviceability or modification, and safety. Due to the modular design, many of the components were sketched separately and designed to fit together into one common unit. Six main modular components define the harvester. Where possible, hydraulic controls for each component were mounted on the tractor.

The first component was the lifter wheel / exit beater assembly, which was salvaged from a surplus harvester. This assembly was mounted on a separate sub-frame in order to engage (lower) or disengage (raise) the unit for transport of harvest, respectively. Typical commercial harvesters move the entire frame to achieve this operation, however, the motion of the entire frame tipping causes an uneven platform that proves to be a safety hazard for personnel working on the harvester. The sub-frame included a hydraulic cylinder to raise and lower this subunit, and since this design caused changes in the lift-wheel mounting angle throughout its range of motion, considerations for the pinch point of the lifter wheels were taken into account to accommodate various operating heights that may be used.

Figure 1: One-row sugarbeet harvesting and analysis platform.
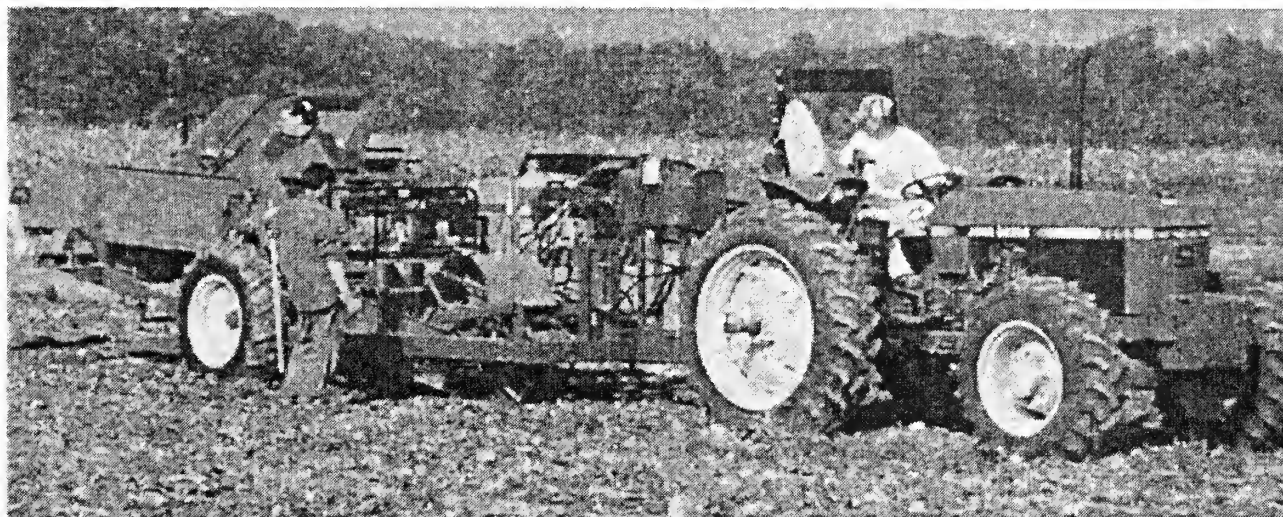
The second modular component was the bed chain assembly. This unit was fabricated from two pieces of 1/8" sheet metal that make up the sides of the conveyor and connected with 2" square tube bracing. It contained an 18" belted chain with steel rods running in a continuous loop. Four eccentric sprockets were mounted (two each side) between the drive and roller sprockets, providing an action that causes dry, loose soil to fall from the roots. The unit was mounted at a 10-degree incline to the field level.

The third modular component was the lift conveyor assembly. This unit was constructed in much the same way as the bed chain assembly, however it was oriented at a 45-degree angle. The bed chain dumps beets onto this unit. These two units are driven by the same hydraulic motor and connected by a 60H roller chain. This third component differed in design in that it used an 18" belted chain with 3" raised steel flights on every fifth link rod. This component did not use the eccentric wheels but incorporated two ultra high molecular weight (UHMW) slides to support the belt between the top and bottom rollers. The approximately 13" wide space between the UHMW is open for small stones, soil, etc. to fall through to the ground. A transition is made between the third and fourth components that allow the beets to fall gently from the lift chain onto the grab rolls.

The fourth component was the grab roll assembly. This assembly consisted of a solid frame with 1/8" sheet metal sides to direct the beets over the grab rolls. The grab rolls have one smooth and one spiral roller. Considering the light load of beets that would actually be

on the rollers at any point of time given the slower harvest speed and one row of material, this combination of rollers gives more bounce to the beet, spinning it around so all sides have equal chances for cleaning while on the grab roll bed. The spiral roller is wrapped with a double spiral to provide additional cleaning ability. This roller is also mounted in a fixed position while the smooth roller is mounted on pivoting axes with an adjustable cushion dampening design to allow for movement should any foreign object wedge between the rollers. A hydraulically powered double belt with a spring tensioner drives the grabs rolls.

The fifth component was the hopper / lift conveyor combination. The hopper included steep vertical angles to facilitate complete cleanout, and connected to the sides of the conveyor for a smooth transition. The lift conveyor chain was the same as component three and the conveyor was set at a 45-degree angle. The steel frame structure built around this conveyor provides support to the four load cells that measure plot weight at this point. Careful planning put all the load cells on the same plane and empty weight was divided 60/40 with 40% on the two load cells on the hopper side. This allows for loading of the hopper and a shift of the weight division back to 50/50 (or somewhat close depending on actual plot weight). A later development prompted a modification to be able to fully secure the load cells from any movement (up, down, or sideways) for transport to avoid damaging the sensors. The lock developed consists of three threaded rods each with four nuts for securing the conveyor. The load cells are attached to the harvester frame to give a very rigid base.

The sixth component was the processing line. This component includes a hopper where beets are delivered from the last conveyor. The line delivers beets back toward the front of the machine. This area was built to be a laboratory bench with a stainless steel top. Incorporated into the bench are a portable scale (used for single beet weight), a saw (for tissue maceration and collection) and an observation / selection area. To be added is a real-time sucrose-sensing instrument, and current plans call for a Near Infrared unit mounted next to the saw focused on the cut surface of the beet.

All of the above components were mounted onto a frame made from 2" x 6" steel tubing. The frame and wheels straddle three 28" rows with the offset being to the left side of the harvester. The offset was designed to give a more stable platform and provide stability for an over-center dump hopper to be added in the future. Two 4900 pound axles with 8 bolt hubs and 12.4-24 R1 tires (oriented in reverse direction) carry the harvester. Some typical harvester components were available on a previously used unit. This included a lifter wheel assembly and exit beater as well as some hydraulic components. A two-point swinging hitch was salvaged from a used John Deere 5 bottom plow. This hitch was necessary to assist in the loading of the implement onto a trailer for transport. A complete list of parts is available from the authors.

The harvester was deployed for the Fall 2002 harvest. It was used on all plots. Comparison of results using the same germplasm grown in adjacent one- and two-row plots showed some differences in yield (see earlier **Table 1**: harvest data for agronomic tests 02BB01 and 02BB02). However, the advantages to our program in using a one-row harvester are many. These include being able to test more germplasm in many diverse environments such as disease nurseries due to the easy transportability of the harvester, needing less seed for planting a single row, and the ability to measure each beet for weight, sucrose, and morphology for selection.

Field Evaluation of Sugar x Red Beet Population Segregating For Sucrose Content And Yield

Daniele Trebbi and J. Mitchell McGrath

Michigan State University and USDA-ARS

Root sucrose concentration is an important heritable agronomic trait for the beet sugar industry. Economic return of the crop is roughly calculated by root yield multiplied by the percentage of sucrose content in the roots. Sucrose content in beets is variable, ranging from less than 8% to more than 18% in red beet and sugar beet, respectively. Genetic and phenotypic analyses of populations derived from wide crosses, such as between red and sugar beets, will provide information about which chromosomal regions and their associated genes are largely involved in sucrose accumulation during the development of the crop. This information will be useful for improving sucrose content in populations constructed to introgress useful genes from wild and unadapted germplasm.

An F_2 segregating population was created from a cross between sugar beet C869 and red beet W357B. C869 is characterized by higher yield and 16% root sucrose content. W357B has lower yield and less than 10% sucrose content at maturity. Carbohydrate analyses were performed via HPLC on each greenhouse-grown F_2 plant and parent. Genetic analysis of this F_2 population was performed with RFLP (Restriction Fragment Length Polymorphisms) and AFLP (Amplified Fragment Length Polymorphisms) genetic markers. A genetic linkage map was constructed, and QTL (Quantitative Trait Loci) analyses for sucrose content was performed integrating data from the F_2 sucrose content analyses and the genetic map (data not shown).

The objective of the progeny test reported here was to better estimate sucrose content of each individual F_2 plant by field evaluation of F_3 families, in order to increase the accuracy of QTL detection. Three replications of 54 F_2-derived F_3 families and six sugar beet lines (US H20, E17, SR87, SR95, SR96 and SR97) were planted in single rows on May 22, 2002 and harvested on October 22, 2002 with the one-row harvester. F_3 families were analyzed for root color, leaves vigor, root water content, root sucrose content (both dry and fresh weight) and yield (Table 1).

Sucrose fresh weight ranged from nearly 16% in the F_3 families to ca. 10% sucrose fresh weight, and no F_3 line showed higher fresh weight sucrose than sugar beet lines with commercially acceptable sucrose contents. No significant difference was observed for sucrose content as a percentage of dry weight. This result was similar to those obtained for greenhouse-grown F_2 plants (data not shown). Root yield of sugar beet germplasm exceeded that of individual F_3 families, and ranged from 81.3 % of the average of six sugar beet lines to less than 30 %. A pre-harvest vigor index was estimated visually, roughly corresponding to canopy characters (e.g. score of 1 was poor canopy development, score of 5 was excellent canopy development). Canopy development of the F_3 families was inferior to sugar beet.

Results suggest that the number of genes controlling fresh weight sucrose content and root yield is not large, and that the fresh weight sucrose content but not dry weight sucrose content is heritable, at least at these levels of analyses. Canopy vigor appears to be inherited in a more complex manner since the sugar beet type of canopy was not recovered among this small set of progenies tested.

Table 1: Analysis of 54 F₃ and six sugar beet lines (USH20, E17, SR87, SR95, SR96 and SR97). Vigor Index was evaluated on a 1 (low) to 5 (high) scale; Root Yield Index was calculated relative to average of six sugar beet lines (=100).

Entry	F₃ Root color	Vigor Index (1)	Root dry weight (%)	Sucrose on dry weight (%)	Sucrose on fresh weight (%)		Root Yield Index (2)	
SR97	-	5.00	26.60	76.77	20.40	a	94.8	abcde
SR96	-	5.00	24.49	75.84	18.52	abc	98.9	abc
E17	-	5.00	24.44	71.83	17.60	abc	92.0	abcdef
101	Segregating	3.00	22.71	70.11	15.98	bcd	51.2	jklmnopqrst
27	Segregating	2.33	21.50	73.48	15.84	bcde	56.6	hijklmnopqrs
42a	Segregating	2.67	22.24	71.57	15.82	bcde	44.9	mnopqrst
71	Segregating	1.33	22.95	69.00	15.81	bcde	29.5	t
38a	Segregating	4.00	22.50	70.03	15.78	bcde	72.1	efghijk
76a	Red	3.00	20.96	74.95	15.72	bcdef	62.2	ghijklmnop
92a	Segregating	2.67	20.86	75.00	15.68	bcdefg	61.4	ghijklmnopq
35	Red	3.00	21.38	72.44	15.61	bcdefg	40.4	pqrst
USH20	-	5.00	20.83	74.18	15.46	bcdefg	105.1	ab
72	Green	2.33	20.92	72.68	15.25	bcdefgh	57.2	hijklmnopqr
84	Segregating	2.67	22.09	68.72	15.20	bcdefgh	52.0	jklmnopqrst
84a	Segregating	2.33	21.35	70.43	15.11	bcdefgh	55.0	hijklmnopqrs
121	Red	2.33	21.56	71.31	15.07	bcdefgh	60.2	ghijklmnopqr
73a	Segregating	2.67	20.91	71.93	15.03	cdefgh	38.5	pqrst
SR95	-	4.33	19.49	76.80	14.95	cdefghi	96.0	abcd
66	Red	3.33	20.61	72.72	14.93	cdefghi	50.5	jklmnopqrst
73	Segregating	3.00	20.76	72.52	14.93	cdefghi	60.7	ghijklmnopqr
63	Segregating	2.67	19.98	72.66	14.54	cdefghi	71.9	efghijk
33	Segregating	2.67	19.21	75.83	14.47	cdefghi	66.0	ghijklmn
94	Segregating	2.00	20.89	68.97	14.43	cdefghi	46.1	mnopqrst
99	Segregating	3.67	19.33	73.61	14.38	cdefghi	81.3	bcdefg
86	Green	1.67	18.97	75.36	14.30	cdefghi	68.6	fghijklm
107	Segregating	3.67	20.03	71.01	14.23	cdefghi	59.9	ghijklmnopqr
110a	Segregating	3.33	20.34	70.03	14.22	cdefghi	66.0	ghijklmn
105a	Segregating	2.33	19.01	74.50	14.19	cdefghi	50.1	jklmnopqrst
72a	Red	3.00	18.92	74.78	14.16	defghi	61.7	ghijklmnopq
127	Green	2.00	19.26	71.94	14.12	defghi	66.8	ghijklmn
75	Red	2.00	18.82	74.10	14.08	defghi	38.0	qrst
29a	Green	1.33	20.02	69.93	14.00	defghi	>3	
82a	Segregating	3.67	19.31	71.78	13.94	defghi	77.7	cdefghi
78a	Segregating	1.33	18.82	73.70	13.93	defghi	45.0	mnopqrst
93a	Red	3.00	19.43	71.52	13.91	defghi	37.3	st
93	Red	3.33	19.69	70.93	13.88	defghi	70.5	fghijkl
76	Red	2.00	19.52	70.70	13.86	defghi	43.9	nopqrst
71a	Green	2.00	19.44	70.30	13.68	defghij	49.7	klmnopqrst
119a	Red	3.00	19.03	71.70	13.62	defghij	44.4	nopqrst
89a	Red	2.67	18.58	72.42	13.45	defghij	33.2	st
59a	Segregating	2.33	19.59	68.55	13.43	defghij	71.0	efghijkl
43a	Segregating	3.33	18.02	73.91	13.36	defghij	54.5	hijklmnopqrs
117a	Green	3.00	18.36	72.49	13.21	defghij	65.4	ghijklmno
125	Green	2.33	18.85	69.73	13.14	defghij	73.7	defghij
27a	Segregating	2.33	18.73	69.27	12.97	defghij	54.7	hijklmnopqrs
31	Segregating	2.00	18.48	70.00	12.96	defghij	64.8	ghijklmno
111	Segregating	2.33	18.87	68.87	12.95	defghij	47.6	lmnopqrst
65	Segregating	1.33	19.13	67.30	12.87	defghij	46.0	mnopqrst
104	Segregating	3.00	17.02	75.69	12.87	defghij	54.8	hijklmnopqrs
79	Red	2.67	18.05	69.67	12.60	defghij	41.7	opqrst
39a	Segregating	2.33	17.37	72.29	12.56	defghij	58.2	ghijklmnopqr
77	Segregating	1.67	17.37	71.93	12.49	efghij	55.4	hijklmnopqrs
123a	Segregating	3.33	17.03	73.39	12.48	efghij	70.3	fghijkl
SR87	-	5.00	18.02	68.20	12.29	fghij	113.2	a
96	Segregating	2.67	16.83	72.82	12.23	ghij	54.1	hijklmnopqrs
103	Segregating	3.00	16.33	72.91	11.90	hij	75.2	cdefghi
122a	Red	2.67	16.74	70.85	11.84	hij	44.8	nopqrst
99a	Segregating	2.00	16.78	70.86	11.79	hij	49.0	klmnopqrst
116a	Segregating	3.00	16.31	70.39	11.48	ij	50.5	jklmnopqrst
95a	Red	2.33	15.23	67.94	10.33	j	52.6	ijklmnopqrst
Mean		2.81	19.68	71.92	14.16		60.3	
LSD (.05)		0.91	4.33	6.82	3.48		23.8	
% CV		35.89	8.88	2.83	9.16		7.61	

D12

Sucrose accumulation during early sugar beet development
Project 743

Daniele Trebbi and J. Mitchell McGrath
Department of Crop and Soil Sciences, Plant Breeding and Genetics Graduate Program,
Michigan State University, East Lansing, MI 48824-1325 USA

This study examined sucrose accumulation in different breeding lines during the first weeks after emergence in order to identify early physiological differences correlated with root sucrose content. At each weekly harvest during the first 10 weeks of growth, roots, leaves, and hypocotyls were weighed and freeze-dried, and hypocotyls diameters were measured. From freeze-dried roots, sucrose was extracted with 80% ethanol and then analyzed with high pressure liquid chromatography (HPLC). Sucrose concentration expressed as fresh weight increased from less than 0.5% at the third week (all germplasm) to over 12% by the tenth week, with measured sucrose levels proportional to those from field-harvested beets. Incremental changes in sucrose levels were not constant during this period, but followed a step-wise trend of rapid sucrose accumulation alternating with low sucrose accumulation. Sucrose concentration expressed as dry weight reached 55% at the 10th week for all lines. During this early developmental stage a time-course differential gene expression analyses (cDNA-AFLP) was performed, and showed that more than 40% of the transcribed genes are differentially expressed in developing roots. Differential gene expression analyses combined with examination of anatomical differences of root tissues during these alternate developmental stages may provide additional insight on the kinetics and molecular mechanisms of sucrose accumulation in sugar beet.

Sucrose content in beet tap roots is inherited as a multigenic trait, in an additive fashion, and with high heritability (Savitsky 1940; Culbertson 1942; Powers 1957; Powers et al. 1963; Zhao et al. 1997). Sucrose distribution within the root is concentrated with the innermost five of the concentric cortical rings, around the point of maximum root girth, and accumulates in vacuoles of parenchyma cells adjacent to vascular tissue (Elliott & Weston 1993). Sucrose biosynthesis, transport, and storage in beets likely occurs by mechanisms similar to other plants, but specific regulatory mechanisms that allow accumulation of sucrose in the roots remain to be identified (Kovtun & Daie 1995, Avigad & Dey 1997, Martin et al. 1997, Bush 1999). Unknown is whether any or all of the enzymes involved in these biochemical processes are important for the accumulation of sucrose in sugar beet roots and which genes, if any, are regulated and would likely play significant roles during sucrose accumulation. The dynamics of sucrose accumulation during the growing season are of interest since early developmental stages are important for the future storage capacity of the root.

The purpose of this research is to develop a genetic model for heritable differences in root sucrose content in different genotypes of sugar beet, and begin to characterize major genes involved in root sucrose accumulation. The specific objective of this report was to examine early plant development stages and correlate developmental initiation of sucrose accumulation with the changes in gene expression during this developmental phase.

Five germplasm lines (USH20, SR87, SR95, SR96, and SR97, ranging in harvested sucrose contents from 15 to 18%) were planted in the greenhouse (20 to 22.5 C, 16 hr light cycle) with three replications. Plant samples were harvested weekly from the third to the tenth week post-emergence for sucrose analyses, and additionally for mRNA extraction

(additionally including the 2nd week). Carbohydrate analyses were performed via HPLC. After freezing, dehydrating, and pulverizing root tissue (<5 week old also included epidermal tissues), sucrose was extracted with 80% ethanol, decanted, vacuum evaporated, and re-suspended in water for HPLC.

Differential gene expression analysis using cDNA-AFLP was performed as described (Bachem et al. 1996). Amplified fragments originating from amplification with dye-labeled *Eco*RI (5' – GACTGCGTACCAATTCNNN - 3') and *Mse*I (5' – GATGAGTCCTGAGTAANN - 3') primers were separated on 7% poly-acrylamide gels using an LI-COR 4200 Automated DNA Sequencer.

Sucrose accumulation results: Sucrose was the main component (>98%) of the extracted sugars, and only traces of glucose and fructose were detected. Sucrose content increased dramatically from less than 2% to more than 10% (fresh weight) between the 5th and 8th weeks (Figure 1). A further smaller increase was observed during the last two weeks of observation when lines reached more than 12% of sucrose in fresh weight. The difference in sucrose content between the lowest sucrose content variety USH20 and the highest sucrose content germplasm SR96 lines was statistically significant after the 6th week post emergence. No significant differences between entries was observed for sucrose content expressed on a dry weight basis, which increased from 5 to more than 55% during the period under investigation (data not shown). Hypocotyl diameters increased exponentially from less than 2.5 to more than 35 mm from the third to the tenth week, without any significant difference between lines.

Figure 1: Sucrose accumulation over eight weeks of early sugar beet growth. Differences between USH20 and SR96 are significant at p=0.10 for weeks 7 & 8, and p=0.05 for weeks 9 & 10).
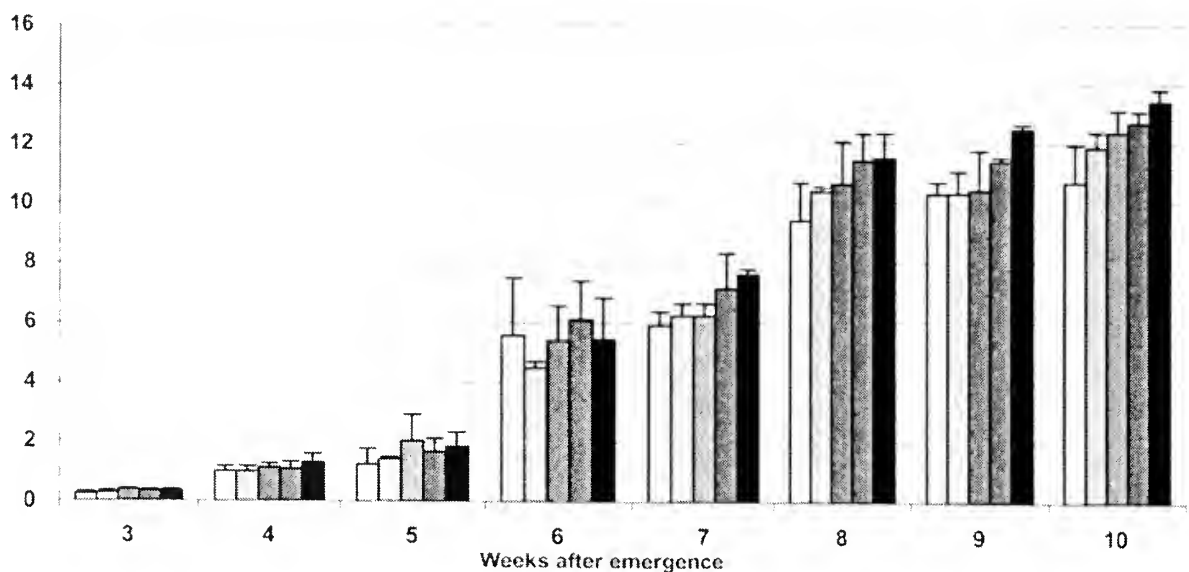
Transcription profiling results: 134 primer combinations were used for cDNA-AFLP analyses. 3,739 amplified fragments, arising from expressed genes, were scored. Most fragments (58%) were invariant, and thus represent constitutively expressed genes. The remaining fragments (42%) varied in their presence or absence in at least one week's sample.

The number of fragments detected tended to decrease with as plant age increased, with the exception of the plants at the 2nd week post-emergence (Table 1). Cluster analysis of fragment presence or absence revealed two distinct developmental periods: before and after the 6th week (Figure 2). A developmental shift in growth during the 6th week is postulated to explain this result.

Table 1: Number of fragments representing expressed genes scored over the time course of experiments.

Week post-emergence	Number of fragments scored	Percent of total fragments
2	3059	81.8
3	3127	83.6
4	3109	83.2
5	2924	78.2
6	2917	78.0
7	2957	79.1
8	2929	78.3
9	2824	75.5
10	2882	77.1
Total	3,739	100.0

Characterizing genes that play major role in sucrose accumulation will facilitate rapid progress in developing high sucrose germplasm releases after introgression of other favorable traits such as disease resistance and stress tolerance genes from wild and exotic germplasm. Early selection would also be facilitated if sucrose content could be measured early in the season. Each of these enhanced breeding strategies appears feasible on the basis of these preliminary experiments since significant differences in sucrose content (fresh weight) are evident as early as 7 weeks after emergence, and the genes responsible for this increase appear to be expressed as early as 5 weeks post emergence. Interestingly, this period also coincides with the onset of field resistance for many seedling pathogens.

Figure 2: Cluster analysis results from expression patterns of 3,739 cDNA-AFLP fragment scored during each week of development from 2 to 10 weeks of age.
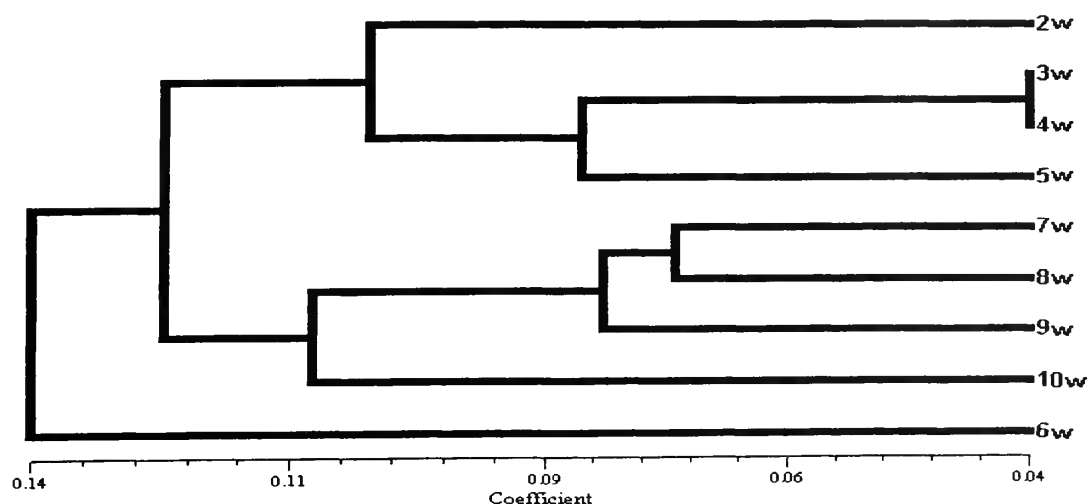
REFERENCES

Avigad G, Dey PM. (1997) Carbohydrate metabolism: storage carbohydrates. In: Plant biochemistry. Dey PM, Harborne JB. (eds), Academic Press, New York pp. 143-204.

Bachem CWB, van der Hoeven RS, de Bruijn SM, Vreugdenhil D, Zabeau M, Visser RG.F (1996) Visualization of differential gene expression using a novel method of RNA fingerprinting based on AFLP: analysis of gene expression during potato tuber development. The Plant J 9: 745-753.

Bush DR. (1999) Sugar transporters in plant biology. Current Opinion in Plant Biol 2: 187-191.

Culbertson JO (1942) Inheritance of factors influencing sucrose percentage in *Beta vulgaris*. J Ag Res 64: 153-172.

Elliott MC, Weston GD. (1993) Biology and physiology of the sugar-beet plant In: The sugar beet crop: Science into practice. Cooke DA, Scott RK (eds), Chapman and Hall, London pp 37-66.

Kovtun Y, Daie J. (1995) End-product control of carbon metabolism in culture-grown sugar-beet plants - molecular and physiological evidence on accelerated leaf development and enhanced gene expression. Plant Physiol 108: 1647-1656.

Martin T, Hellmann H, Schmidt R, Willmitzer L, Frommer WB. (1997) Identification of mutants in metabolically regulated gene expression. Plant J 11: 53-62.

Powers L, Schmehl WR, Federer WT, Payne MG. (1963) Chemical genetic and soil studies involving thirteen characters in sugar beets. J Am Soc Sugar Beet Tech 12: 393-448.

Powers L. (1957) Identification of genetically-superior individuals and the prediction of genetic gains in sugar beet breeding programs. J Am Soc Sugar Beet Tech 9: 408-432.

Savitsky VF. (1940) Genetics of sugar beets. USDA-National Agricultural Library Translation 5825. Translated from Russian, original source unavailable. 135 pp.

Zhao B, Mackay IJ, Caligari PDS, Mead R. (1997) The efficiency of between and within full-sib family selection in a recurrent selection programme in sugar beet (*Beta vulgaris* L). Euphytica 95: 355-359.

Alphabet soup for beets: status of ESTs, BACs, RILs and other genomic sundries

J. Mitchell McGrath

Dogma holds that phenotype = genotype + environment; DNA makes RNA makes protein; and form follows function. What this means is that the beet's work is accomplished in large part by proteins; that proteins (via genes) are inherited from the parents; and expression of genes is influenced by environment (and also development). By understanding beet proteins deduced from gene sequences, whose function can be inferred from other well-characterized protein forms, we can begin to build a conceptual framework for the types of work that a beet must accomplish in order to be profitable to growers and industry. This report considers the progress in building the tools that will enable such a framework. For instance, as of February 2003, over 19,500 Expressed Sequence Tags are available, a 5X coverage Bacterial Artificial Chromosome library has been constructed, and 5,000 Recombinant Inbred Lines are being developed. These efforts have and will continue to

require close cooperation among ARS, industry, and academic scientists. These tools are freely available now and will likely remain so in the future. Already, problems previously considered intractable are beginning to yield insight upon application of these tools. Progress is likely to accelerate in the future, as these genomics investments can be leveraged with scientific expertise inside and outside of the sugar beet community.

Genomics is a logical extension of concepts developed over the past 200 years that combine plant and animal breeding, cell biology and biochemistry, genetics, and molecular biology and physiology. It is integrative in that these disparate disciplines are united at the description and function of the myriad cell types in various tissues at the level of the gene. Genomics attempts, therefore, to describe the structure and function of every gene in the genome, in every cell and tissue type, and begin to understand the hierarchy of gene interactions that ultimately result in phenotype.

Functional genomics, or global analyses of gene expression, fills a gap between traditional biochemical analyses and the genetic instructions for these gene products encoded in the DNA, as represented by expressed RNA molecules (e.g. genes). Analyses of these transcripts by nucleotide sequencing (or other methods) reveals information about the identity and abundance of a specific transcript, the diversity of transcripts present in specific cells and tissues, and the biochemical complexity of an organism. Potentially novel or unexpected solutions to specific developmental or environmental cues may also be evident from such analyses.

Gene expression is the realization of genetic potential. Gene expression results in phenotype, which itself is the interaction of genotype and environment. While the genotype is accessible through inheritance and selection over generations in different environments, phenotypic expression of specific traits is often limited spatially or temporally, in effect accumulating throughout the growing season. Phenotypic responses to abiotic (and biotic) stresses may be predictable, but complex, particularly in combinations that would be expected under the diversity of field environments where beets are grown. Global gene expression analyses can help understand this complexity by determining which gene products are regulated under each type of stress. Each regulated gene product would have some probability for involvement in response to stress, and would represent a target for breeding and selection. Global gene expression analyses have been unavailable to plant breeding prior to large scale sequencing projects.

A prerequisite to global gene expression profiling is knowledge of nucleotide sequences of expressed genes. The typical approach to gaining this information has been to sequence cDNA (complimentary or copy DNA, reverse transcribed from mRNA) clones, which by definition are derived from expressed genes. These sequences are compared for similarity to the ever-increasing number of nucleotide sequences held in databases, and sequences with high similarity to genes with known function are used to assign putative functions. A catalog of expressed genes is often generated by mass sequencing of cDNA libraries, each cDNA clone being sequenced a single time, resulting in a collection of Expressed Sequence Tags (ESTs). ESTs by definition are preliminary and unsubstantiated indications of actual nucleotide sequences.

Depending on the level of similarity between any two sequences, a putative protein functional class can be assigned for many ESTs (Burks, 1999). Most functional classes belong

to biochemical pathways, so a complete set of nucleotide sequences for an organism defines the biochemical reactions that can occur. Differential expression of genes, particularly among genes of a common pathway, provides a measure of the importance of any particular biochemical process in a particular environment. This information can be used directly for selection and breeding.

The first complete nucleotide sequence of a plant genome, *Arabidopsis thaliana*, was completed in 2000 (The *Arabidopsis* Genome Initiative, 2000), providing an unparalleled opportunity to access plant genes. Gross characterization of *Arabidopsis* gene content revealed features that have relevance for plant improvement. First, *Arabidopsis* has on the order of 25,000 genes. In relation to other fully sequenced multicellular eukaryotic genomes of fruit fly (*Drosophila melanogaster*) and nematode (*Caenorhabditis elegans*), *Arabidopsis* shared most similarity in genes with basic metabolic functions and shared least similarity in genes that sense and respond to environmental and developmental signals. Sugar beet is expected to be similar at a gross level to *Arabidopsis*, although differences in gene regulation, gene copy number, and presence or absence of specific gene classes might be expected.

One of the tasks for sugar beet research will be to determine which specific genes are of interest in germplasm improvement. Having a list of genes expressed in sugar beet is one of the earliest objectives that need to be accomplished. It is perhaps cost prohibitive to sequence the entire sugar beet genome presently, but EST projects are more affordable and a great deal of progress on this objective has occurred recently. Insufficient time has elapsed to have fully explored these new resources, and rapid progress can be expected. As of February 2003, over 20,000 *Beta vulgaris* nucleotide sequences had been deposited in the National Center for Biotechnology Information (i.e. GenBank, www.ncbi.nlm.nih.gov). The majority of these are ESTs (19,617 sequences). ESTs have been submitted by three independent groups (USDA-ARS East Lansing, Max Plank - Cologne, and the GABI project) from mRNAs expressed in seedlings germinating under stress, four week old roots, mature roots, storage roots, leaves, and inflorescences. The GABI set is unique in that clones were pre-selected prior to sequencing to remove a large proportion of redundant transcripts (Herwig et al. 2002), and thus represents a 'unigene' set of over 10,000 unique expressed gene sequences covering the important developmental stages of beet growth. Sugar beet researchers now have perhaps one third of the expected expressed genes available to evaluate.

Expressed gene sequences contain information required for the translation of the genetic code into proteins, the molecules that accomplish much of the cell's work. They do not generally contain information required for the correct expression of their respective proteins; however these instructions are often located close to the gene, generally immediately adjacent. Thus, complete characterization of a gene involved in expression of an agronomic trait requires sequencing of these promotor regions. As perhaps 60% of the 750 million base pair beet genome is comprised of non-protein encoding sequences, isolating the adjacent sequences to expressed genes can be problematic. Bacterial clones are available with very large segments of sugar beet DNA inserted with them and the task of screening such large insert libraries is proportionately less intensive. This strategy has been successful in numerous genomics programs, and a number of BAC (bacterial artificial chromosome) libraries have been constructed for beet. Additionally, BAC libraries are useful starting points for complete genome sequencing, as well as estimating the number of genes similar to any particular EST, as a measure of genetic redundancy in the beet genome.

In collaboration with USDA-ARS scientists at Fargo, ND; Ft. Collins, CO; and Salinas, CA, a BAC library with five-fold genome coverage (38,400 clones) was constructed from *Hin*DIII-digested sugar beet hybrid USH20, with an average insert size of 100 – 125 kb. Filter arrays were prepared that contained all clones and were used to assess the abundance and distribution of particular types of nucleotide sequences via filter-hybridization approaches. Using a ribosomal RNA gene probe, 1.2% (450 clones, estimated to total 9,500 copies of a presumed 10 kb repeat unit) of the library carried sequences similar to these highly repetitive, highly conserved sequences located on Chromosome 1 of the Butterfass trisomic series (Schondelmaier & Jung 1997). A simple sequence repeat element $(CA)_8$ thought to be predominantly distributed throughout centromere regions of all chromosomes was present in 1.6% of clones (Schmidt & Heslop-Harrison 1996). A probe for the telomere canonical sequence $(TTAGGG)_7$ only hybridized with seven BAC clones; however this region at the end of chromosomes is difficult to clone and was not expected to be well represented in this library, and may represent interstitial relics from previous inversion events. Organelle DNA (plastid and mitochondria) contamination was assessed with organelle-specific DNA probes. Chloroplast DNA contamination was greater than mitochondrial DNA (1.6 % of clones vs. 0.01%, respectively).

Twenty-eight randomly chosen ESTs were screened against nylon filter arrays of the BAC library (Table 6). These sequences represent a small sampling of structural and regulatory gene sequences. Assuming 5X coverage, the number of gene copies similar to a particular EST in the beet genome was estimated from the number of hybridization signals. For over half of the ESTs used as probes, a greater than expected number of hybridization signals were observed for a single copy sequence, suggesting that many genes are duplicated in the beet genome. It is possible that some of these duplicated sequences provide strict redundancy of gene function, while others may have sufficiently diverged and may have altered gene expression patterns or functions.

ESTs, as representatives of expressed genes, and BACs, as representatives of the position and number of these genes in the beet genome, provide virtually no information on the agronomic importance of these nucleotide sequences. These traits can be correlated with genetic position through various genetic mapping approaches yet knowledge of the gene functions that underlie agronomic traits are not easily discerned. Correlating gene identity with agronomic function is an important goal, and one approach to achieve this is via integration of gene expression profiling and physical and genetic maps. Since beets are out-crossing and wind pollinated, relatively large amounts of heterozygosity are present in populations available for genetic analyses. Heterozygosity, i.e. genetic variability, adds to environmental variability in measurements of field performance, and reduces precision of genetic analyses in beets.

Recombinant Inbred Lines (RILs) help to accomplish two goals simultaneously. First is the reduction of heterozygosity through inbreeding, and the attendant advantage of potentially allowing better environmental variance estimates. Second is genetically mapping agronomic traits more precisely by allowing large seed productions of defined, identical-by-decent genotypes for multi-location, multi-year estimates of quantitative agronomic traits. Currently, a target for development is 50 RIL populations of 100 individuals each, derived from single seed descent of individual self-fertile hybrid plants for five or six generations. A large range of germplasm is being used, including disease resistance donor germplasm, high and low

sucrose breeding lines, and various crop and wild relatives of sugar beet.

Sugar beet genomics is an extension of traditional breeding and modern genetic methods. Its fundamental utility lies in the ability to define specific elements of the genome, initially in terms of nucleotide sequence and later in terms of specific function. Many long-standing production problems related to variety will be accessible through genomic analyses, and biochemical mechanisms for breeding and selection efficiency will be evident. Sugar beet breeders need to incorporate this knowledge into breeding programs, and should be involved in interpreting genomic information

Table 6: Estimated gene number of ESTs deduced with filter hybridization of the BAC library.

Putative EST function	Genbank ID	Estimated # genes
ABC transporter	BI543560	1
adenine triphosphatase	BI543538	3
allergen	BI095948	2
beta amyrin synthase	BF011005	1
germin-like protein	AF310017	8
calmodulin	BI096069	1
carboxyphosphonoenol pyruvate mutase	AW697745	1
cystein protease	BE590278	1
enolase	BI543290	1
heat shock protein 81-2	AW697750	1
heat shock protein	BI543424	1
hydroxymethyltransferase	BI095900	7
malate dehydrogenase	BI073206	2
UDP glucose pyrophosphorylase	BI096068	3
alcohol dehydrogenase	AW697786	1
aquaporin	BI643109	4
sucrose synthase	BI543240	8
ribosomal RNA genes	pTA71	950
ribulose bisphosphate carboxylase	BI643066	3
MAP kinase	BQ060614	1
UDP-glucose glucosyltransferase	BI073142	2
ribulose phosphate 3-epimerase	BI073233	2
pyruvate dehydrogenase-1	BI073208	3
pyruvate dehydrogenase-2	BI096005	6
hexokinase	BI543276	1
glyceraldehyde 3P dehydrogenase	BI095991	4
isocitrate lyase	BI095941	1
14-3-3 like protein	BI543270	1
phosphofructokinase	BI096032	2

References

Burks, C. 1999. Molecular biology database list. Nucleic Acids Research 27:1-9.

Gindullis F, Dechyeva D, Schmidt T. 2001. Construction and characterization of a BAC library for the molecular dissection of a single wild beet centromere and sugar beet (*Beta vulgaris*) genome analysis. Genome 44: 846-855.

Herwig R, Schulz B, Weisshaar B, Hennig S, Steinfath M, Drungowski M, Stahl D, Wruck W, Menze A, O'Brien J, Lehrach H, Radelof U. (2002) Construction of a 'unigene' cDNA clone set by oligonucleotide fingerprinting allows access to 25 000 potential sugar beet genes. Plant J. 32: 845-857.

Loudet O, Chaillou S, Merigout P, Talbotec J, Daniel-Vedele F. (2003) Quantitative trait

loci analysis of nitrogen use efficiency in Arabidopsis. Plany Physiol. 131: 345-358.

Schmidt T, Heslop-Harrison JS (1996) The physical and genomic organization of microsatellites in the sugar beet. Proc. National Academy of Sciences USA 93: 8761-8765.

Schondelmaier J, Jung, C (1997) Chromosomal assignment of the nine linkage groups of sugar beet (*Beta vulgaris* L.) using primary trisomics. Theoretical and Applied Genetics 95:590-596.

The *Arabidopsis* Genome Initiative. 2000. Analysis of the genome sequence of the flowering plant *Arabidopsis thaliana*. Nature (London) 408:796-815.

Differential expression of glyoxylate enzymes in sugar beet related to seedling vigour
Project 741

Benildo de los Reyes * and J. Mitchell McGrath
* present address: Department of Crop, Soil and Environmental Sciences, 115 Plant Science Building, University of Arkansas, Fayetteville, AR 72701 USA

One component of seedling vigour is the efficient utilization of the seed storage reserves to provide energy necessary for growth. This study examined the relationship between the genes of energy metabolism and differences in seedling vigour of sugar beet hybrids under different stress germination regimes. Analyses of 1,718 5' Expressed Sequence Tags (ESTs) from subtracted cDNA libraries, combined with gene expression profiling by northern blots and enzyme activity assays indicated that stress drastically reduces the expression of a α-amylase in a poor-emerging sugarbeet cultivar. In contrast, a good emerging variety exhibited only a moderate reduction in α-amylase gene expression. This pattern of gene expression indicates that mobilization of energy from stored carbohydrates can be limited to various extents by abiotic stresses. As mechanism to cope with reduced carbohydrate catabolism, the good-emerging, but not the poor-emerging, variety appeared to catabolize lipids as supplementary source of energy for respiration and biosynthetic processes. Induction of glyoxylate cycle activity, whose pathway bridges lipid and carbohydrate metabolism in germinating seeds, was indicated by high transcript levels and increased enzyme activity for the key glyoxylate cycle enzymes isocitrate lyase and malate synthase. The differential activity of the glyoxylate cycle is a potential physiological marker to differentiate between high- and low-vigour sugarbeet cultivars.

Our objectives have been to examine germination of sugar beet under sub-optimal environments and to identify physiological and developmental opportunities for intervention by traditional and marker-assisted breeding. As one approach, we developed Expressed Sequence Tags (ESTs) from subtracted cDNA libraries of a high vigour sugar beet hybrid in order to gain some insight into gene expression during germination under stress.

Seedling vigour *a priori* involves the coordinated regulation of many genes in various biochemical pathways, including mobilization of seed storage reserves. Starches are an important energy reserve in beet seed, and lipids and proteins also are present. Ware (1898) refers to a number of chemical constituents of beet seed, and indicated a starch content of 39.6% primarily located in the perisperm (maternally –derived endosperm-like tissue), a

protein content of 27.6% primarily located in the embryo, and 20.5% lipid content distributed throughout the perisperm and embryo. Elamrani et al. (1992) showed virtually no lipid in the perisperm but a lipid content in the embryo around 15%, showing that lipids are likely to be the initial respiratory substrate during germination of sugar beet, with carbohydrates assuming greater importance after radicle protrusion from the seed ball. Similarly, Lawrence et al. (1990) showed differences in organ specific starch, protein, and sugar contents in excised seeds and seedlings, and suggested a specialization of the inner cotyledon (in closest proximity to the perisperm) in carbohydrate uptake.

Involvement of lipid metabolism in beet seedling vigour was suggested by the presence of Expressed Sequence Tags (ESTs) for germination specific, lipid catabolizing enzymes of the glyoxylate cycle in stress germinating beet seed *in vitro*. The abundance of key glyoxylate cycle enzymes isocitrate lyase (E.C. 4.1.3.1) and malate synthase (E.C. 4.1.3.2) in stress- and H_2O_2-induced EST libraries raised the question of the importance of lipids as energy source during germination and seedling emergence under sub-optimal environments. In this study, we present evidence of differential activity of carbohydrate and lipid catabolic pathways in germinating seeds based on gene expression analysis and their physiological importance to seedling emergence and vigour in sugar beet cultivars.

Materials and methods

Seed germination: High quality seedlots (average germination >92%) of hybrids USH20 (strongly emerging) (Coe and Hogaboam, 1971) and ACH185 (weakly emerging) (American Crystal, Moorhead, MN) were used. Germination was performed as described (de los Reyes and McGrath, 2003). Percentage germination (radicle length ≥2 mm) was determined daily from four replicate experiments.

Isocitrate lyase activity assay: Soluble protein extracts from control and solution-germinated seedlings were prepared at 2 to 8 days after imbibition. Isocitrate lyase activity was determined by the lactate dehydrogenase (LDH)-coupled continuous assay (Giachetti et al., 1983).

Results

1,718 ESTs (Expressed Sequence Tags) were obtained from three subsets of cDNA. One EST subset was derived from 415 cDNAs that were randomly chosen from an unsubtracted cDNA library of stress-germinated 4-day-old seedlings. Two other EST subsets represent the collections of salt-induced (871 ESTs) and H_2O_2-induced (432 ESTs) genes. This EST collection does not represent the total array of genes that were expressed, but was enriched with genes related to growth and development, stress response and transcription.

Grouping ESTs according to putative biochemical function showed that 7.2% of cDNAs from the whole collection represented known genes in carbohydrate or lipid catabolic pathways. For carbohydrate utilization, transcripts encoding starch and polysaccharide hydrolytic and debranching enzymes were numerous (1.5%). Transcripts for □-amylase were the most abundant EST under this functional category (0.3%), and this gene serves as a physiological marker for carbohydrate breakdown. Not all genes in the primary pathways for sugar catabolism, i.e. glycolysis, oxidative pentose phosphate pathway and tricarboxylic acid cycle were represented, but their activities were indicated by the occurrence of transcripts encoding more than half of the enzymes (3.8%).

The importance of lipids during germination was implied by the relatively high frequency of transcripts for lipases and fatty acid hydrolytic enzymes (0.6%). Activity of the fatty acid $\square$-oxidation spiral was indicated by the EST for acetyl-CoA acyl transferase (0.1%). The glyoxylate cycle was also active as shown by high percentage of transcripts (1.2%) for glyoxysomal enzymes isocitrate lyase and malate synthase. Isocitrate lyase is the key glyoxylate cycle enzyme that links fatty acid oxidation and sugar metabolism via the succinate produced from glyoxysomal acetyl-CoA, and is specific to seed germination. These data suggest that glyoxylate cycle activity may be a critical factor for successful emergence under sub-optimal environments.

The effects of H_2O_2, submergence and salt stresses on the expression of stored energy reserve catabolism genes were compared between USH20 and ACH185. In roots and leaves, isocitrate lyase and malate synthase expression was either low or undetectable, acetyl-CoA acyl transferase was expressed at very low levels, while $\square$-amylase was undetectable.

In US H20 seedlings, $\square$-amylase expression was high in control (filter paper germination) and H_2O_2 treatments and was reduced slightly by stress. In contrast, $\square$-amylase expression in ACH185 was high in non-stressed seedlings but severely reduced by solution stress (water and salt).

All solution germinations induced expression of isocitrate lyase, malate synthase, and acetyl-CoA acyl transferase in USH20. In contrast, submergence and salt stress caused severe reduction in these transcript levels in ACH185. Expression in H_2O_2 remained high and was comparable to the filter paper control. Expression of isocitrate lyase, malate synthase, and acetyl-CoA acyl transferase appeared coordinately regulated by stress and H_2O_2.

Conclusion

Germination and early seedling growth rely on the maintenance of energy supply from seed storage reserves. The glyoxylate cycle allows plants to utilize lipids as a carbon source. Under optimal conditions, the glyoxylate cycle was highly active in germinating sugar beets. The data presented here provide evidence that oxidation of fatty acids and the glyoxylate cycle in a strongly emerging sugar beet hybrid were more active under stress than under optimal conditions. Activity of $\square$-amylase was significantly reduced by stress, and reduction of the rate of carbohydrate catabolism was more severe in the weakly emerging than in strongly emerging hybrid. Based on this relationship, the carbon intermediates derived from lipids via the glyoxylate cycle is an important component of seedling vigour in sugar beet.

The glyoxylate cycle has two important physiological functions: 1) the provision of carbon intermediates from lipid metabolism for sucrose biosynthesis, and 2) replenishment and maintenance of the tricarboxylic acid cycle under conditions when most intermediates are being withdrawn for biosynthetic processes (anapleurotic function). The glyoxylate cycle utilizes acetyl-CoA derived from fatty acid oxidation for the biosynthesis of the four carbon compound succinate, which is then exported and converted to malate in the mitochondria via succinate dehydrogenase (Kornberg and Beevers, 1957). Malate can be utilized for sucrose biosynthesis via gluconeogenesis. Sucrose is then transported to different parts of the seedlings to support post-germinative growth. These data indicate that the coordinate induction of isocitrate lyase, malate synthase, and acetyl-CoA acyl transferase by stress occurred both before and after radicle elongation. Since cellular adaptation to stress conditions require massive changes in gene expression, purine and pyrimidine biosyntheses

that utilize tricarboxylic acid cycle intermediates as substrate, the carbon intermediates produced from the early induction of the glyoxylate cycle were probably not utilized for gluconeogenesis but as an anapleurotic pathway for the tricarboxylic acid cycle.

References

Coe GE, Hogaboam GJ (1971) Registration of USH20 sugar beet. Crop Science 11:942.

De los Reyes BG, McGrath JM (2003) Cultivar-specific seedling vigor and expression of a putative oxalate oxidase germin-like protein in sugar beet (*Beta vulgaris* L.). Theoretical and Applied Genetics (in press).

Elamrani A, Raymond P, Saglio P (1992) Nature and utilization of seed reserves during germination and heterotrophic growth of young sugar beet seedlings. Seed Science Research 2:1-8

Giachetti E, Pinzauti G, Vanni P (1983) A continuous optical assay for isocitrate lyase. Experientia 40:227-228.

Kornberg HL, Beevers H (1957) The glyoxylate cycle as a stage in the conversion of fat to carbohydrate in castor beans. Biochimica et Biophysica Acta 26:531-537

Lawrence DM, Halmer P, Bowles DJ (1990) Mobilisation of storage reserves during germination and early seedling growth of sugar beet. Physiol Plant 78:421-429

Ware, LS (1898) Sugar beet seed. Orange Judd Co. Chicago, IL. 264 pp.

Histopathology and histochemistry of Rhizoctonia seedling damping-off.
Project 742
Subashini Nagendran and J. Mitchell McGrath
Michigan State University and
USDA – Agricultural Research Service, East Lansing, MI

Sugar beet is afflicted by both biotic and abiotic stresses during field germination, emergence, and stand establishment. The germination phase appears to be most sensitive to abiotic stress, mainly drought. Field emergence counts performed over recent years show an association of maximal emergence with moisture availability (*i.e.* higher moisture leads to higher emergence counts). Varieties also differ markedly with respect to field emergence, and molecular mechanisms for this difference are becoming apparent.

Following maximal emergence, stand counts invariably decline, which can be attributed to biotic stress (e.g. seedling disease). Disease causing organisms isolated from dying sugar beet seedlings include *Pythium ultimum*, *Rhizoctonia solani*, *Aphanomyces cochlioides*, and *Phoma beticola* (Halloin & Johnson, personal communication). The relative impact of any one of these diseases probably differs with available moisture and the soil temperature, leading to a complex seedling decline syndrome. Our efforts will continue to be geared towards seeking genetic resistance at the early seedling stage for each of these organisms in less complex conditions (e.g. greenhouse, growth chamber, and laboratory).

The loss to disease caused by Rhizoctonia is estimated to be about 2% in the USA (Duffus 1986). *Rhizoctonia* species are ubiquitous and variable soil inhabiting fungi. Many are saprophytic while others cause economically important diseases on crop plants such as sugar beet, cereals, potato, vegetables, and fruit trees. *R. solani* causes both seedling disease

and crown and root rot in mature sugar beet plants (Herr, 1996). *R. solani* (Teleomorph: *Thanatephorus cucumeris* ((Frank) Donk) is multinucleate, heterothallic, class mycelia sterilia, and is grouped based on anastomosis group (AG), defined as somatic incompatibility between hyphae of different strains (Anderson, 1982). Further work is necessary to resolve taxonomic complexity within anastomosis groups (Oscar Salazar et al 2000, Panella et al. 1997). Different AGs penetrate the host plant differently. *R. solani* primary invasion sites in sugar beet are lower surface of petioles in contact with soil; natural cracks in the crown, lentils on the taproot, and lateral roots. Isolates of AG 2-2 and AG 1 directly penetrate petioles through stomata, AG 4 penetrates from an infection cushion, and AG 5 from appressoria. Following penetration, AG2-2 isolates progressively invade and colonize vascular tissues whereas invading hyphae of AGs 1, 4 and 5 are limited to the cortex. Rhizoctonia seedling diseases of sugar beet differ in pathogenicity and virulence from those causing root rot on older beets (Herr, 1996). The mode of penetration and the progress of subsequent tissue colonization play important roles in Rhizoctonia causing diseases. AG 2-2 and AG4 infect sugar beet seedlings and AG2-2 causes crown and root rot (Sneh et al 1996).

There is no reported resistance to seedling damping-off caused by Rhizoctonia. The overall objectives of these studies are to (1) Screen sugar beet breeding lines for resistance to Rhizoctonia seedling damping off and examine the relationship between seedling damping off and Rhizoctonia crown and root rot, (2) Analyze the histopathology and histochemistry of the sugar beet seedling - *Rhizoctonia solani* infection under compatible (disease) and incompatible (no disease) interactions, and (3) Survey protein profiles of compatible and incompatible interactions to assess the number of magnitude of changes correlated with each phenotype. A reliable screening method is needed to satisfy these objectives, and this report deals with development and results of screening to date.

Materials and Methods

Screening Rhizoctonia seedling damping off: US H20 sugar beet seeds were soaked in 0.3% hydrogen peroxide for 24 hrs and allowed to germinate on water soaked filter paper for 48 hrs. Pots (9 cm dia by 8 cm deep) on cafeteria trays were filled to 2 cm below the top with "Baccto" high porosity soil. Four germinated seeds were planted per pot and grown in a growth chamber (20 C, 20 hr light and 4 hr dark photoperiod), watered daily, fertilized weekly, and thinned to three plants for the test.

Four isolates of *Rhizoctonia solani* isolated from sugar beets were used (kindly characterized and provided by Drs. Lee Panella and Linda Hansen, USDA-ARS, Ft. Collins, CO), one each of a virulent and avirulent strain of AG2-2 and AG4. Isolates tested for growth on a number of media (data not shown), with Corn Meal Agar (CMA) in Petri dish at room temperature showing suitable growth for preparation of inoculum. De-hulled seeds of millet, sterilized on three consecutive days at 120°C for 20 minutes each day, were placed as single layer on the actively growing 3 day old CMA fungal culture and were incubated at room temperature in the light for an additional four days. The millet was completely colonized with the fungus, and this was used as the inoculum. Two-week old seedlings were inoculated with fungus colonized millet seeds. Each seedling was inoculated by surrounding each plant with 10 fungus-infected millet seeds 2 cm from each seedling. Control plants were inoculated with uninfected, sterile millet. Five pots (15 plants total) were inoculated per isolate.

Post inoculation observations were made at 24 hour intervals and the symptoms were recorded as: 0 = Healthy, 1 = Slight penetration scar visible to naked eye, 2 = Deep penetration scar very visible, 3 = Plant showing damping off symptoms, hypocotyl (stem) shows water soaked lesions, 4 = Plant damping off, leaves wilting, 5 = Plant dead. Fifteen seedlings per treatment (fungal strain) were scored by three independent observers and the average score was reported as disease index (DI).

Testing accessions for resistance to Rhizoctonia seedling damping off: Seven accessions were tested with the protocol developed. The accessions were chosen for their crown and root rot ratings based on GRIN scores of 1 (highly resistant to Rhizoctonia crown and root rot) to 9 (highly susceptible to Rhizoctonia crown and root rot). Accessions included PI 590754 (rating 1), PI 591335 (4), PI 590660 (6), PI 590669 (7), PI 490095 (8), PI 470093 (9), and US H20 as a moderately susceptible control.

Results

A reliable and reproducible assay was developed based on inoculating two-week old seedlings and scoring their disease reaction. All isolates caused disease (Figure 1). Only the virulent isolate of AG2-2 caused complete loss of plants in the experiment. Disease severity increased in all isolate-inoculated plants until five days (120 hr) after inoculation, reached a plateau for one day, and then either lessened in the case of AG4 and avirulent AG2-2, or further increased in plants infected with virulent AG2-2. These results suggest that a host – pathogen interaction occurs around five days post-infection that ultimately determines the fate of the plant later in the season. These results also suggest that field infection occurs early in the season.

Figure 1: Disease progress curve US H20 infected with *Rhizoctonia solani*. AG2-2 (W2) and AG4 (R6) are virulent isolates.
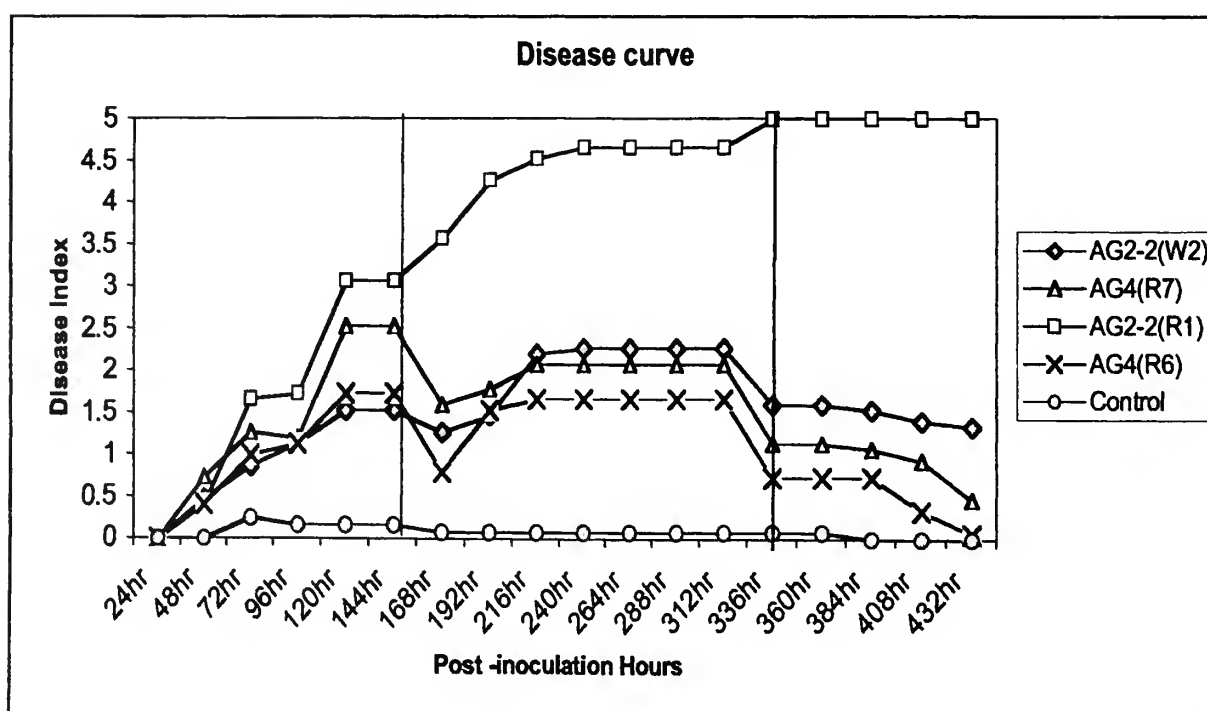
The disease index analysis showed three stages in this plant-pathogen interaction (Figure 1). The initial infection stage from 0 to 144 hours were characterized by rapid appearance of symptoms, the second phase from 192 to 312 hours was characterized by little disease progression, and the final phase 336 to 432 hpi finalized the outcome of the interaction, either death (incompatible interaction) or recovery (compatible interaction). Virulent AG2-2 (R-1) caused seedling damping-off and seedlings infected with other three isolates (AG2-2 W-2, AG4 R6 and R7) showed fewer damping-off symptoms. Similar patterns were observed when different sugar beet lines were inoculated with *R. solani* (Figures 2 and 3). These data suggest that a sugar beet bred line that is resistant to crown and root rot does not confer resistance to seedling damping off.

Figure 2: Disease index for different sugar beet bred lines inoculated with *R .solani* AG2-2 strain R1 (virulent).
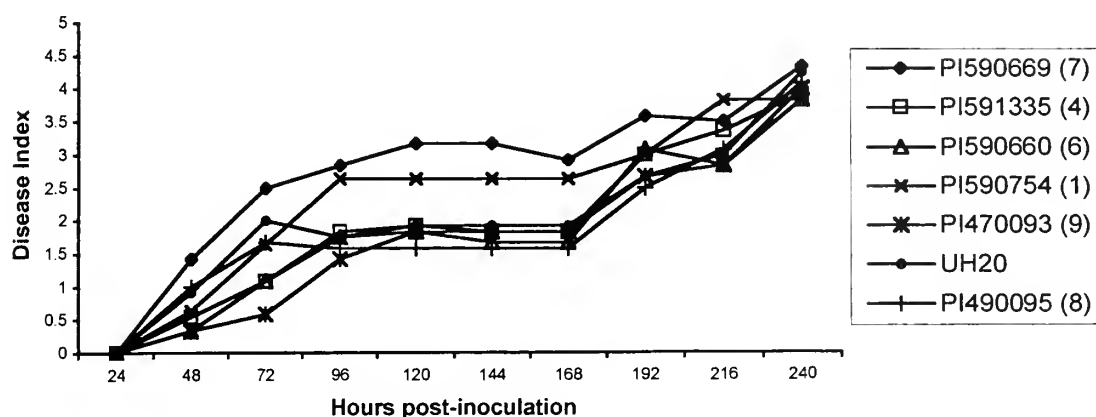
Figure 3: Disease index for different sugar beet bred lines inoculated with *R. solani* AG2-2 strain W2 (hypo virulent).
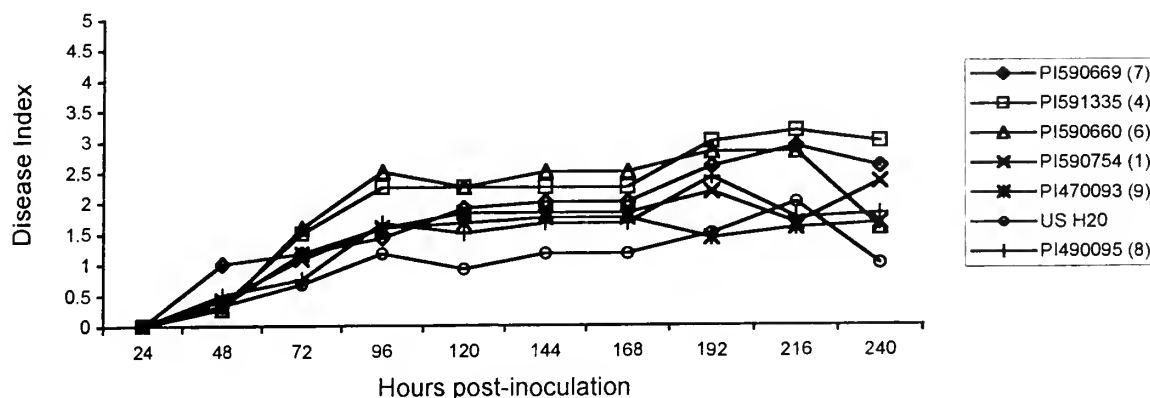
References

Anderson NA (1982) The genetics and pathology of *Rhizoctonia solani* Annu. Rev. Phytopathol. 20:329-347

Herr LJ (1996) Sugar beet diseases incited by Rhizoctonia species. In: Rhizoctonia species: taxonomy, molecular biology, ecology, pathology and disease control. Eds Baruch Sneh, Suha Jabaji-Hare, Stephen Neate and Gerda Dijst. 341-350.

Lindsey K, Casson S, Chilley P (2002) Peptides: new signaling molecules in plants. Trends in Plant Science. 7:*2*:78-83

McGrath JM, Derrico CA (2000) Field evaluation of emergence under seedling disease pressure. 1999 Beet Sugar Development Foundation Research Report, E3-E7.

Panella L, Mitchell S, Jester C, Dean R, Ruppel EG, Kresovich S (2002) Determination of genetic relationship among isolates of *Rhizoctonia solani* Kuhn based on DNA sequence. http://www.crl.ars.usda.gov/determine.htm.

Development of Recombinant Inbred Lines in *Beta*
J. Mitchell McGrath

Construction of defined populations segregating for many traits has been ongoing at East Lansing over the past four years. A strategy was taken initiated to capture genetic diversity of self-incompatible, open-pollinated USDA-ARS releases, wild species, and crop relatives [fodder and table (red) beets, and chard] in a self-fertile genetic background. Self-fertility enforces inbreeding, allowing unexploited opportunities to develop F_2 (syn. S_2) populations for genetic mapping and for progeny testing F_3 (syn. S_3) populations for disease resistance and other agronomic evaluations. Over 100 self-fertile hybrid populations have been made to date yet remain to be characterized. *Bona fide* hybrids were made between self-fertile sugar beet and various *B. vulgaris* accessions representing the agronomic and morphological diversity of the species and ARS releases. These include, among others, hybrids with a common seed parent accession (C869, Lewellen unpublished, Curly Top virus resistance) with EL50 and US201 (both with *Cercospora* leaf spot resistance), USH20 (seedling vigor, Coe & Hogaboam 1971), EL51 (Rhizoctonia crown and root rot resistance), EL48 and SP6822 (Aphanomyces resistance), SR94 (smooth-root morphology), F1016 (root maggot resistance, Campbell et al. 2000), EL0204 (rhizomania resistance, McGrath & Lewellen, unpublished), GW359 (root aphid resistance), SP85303 (oomycete resistance), L19 (high sucrose), KleinE (yield components), fodder beet (Mammoth Red and Wintergold), Table beet (W357B, Indian Table beet), Chard (leaf type), individuals from 100 Plant Introduction accessions that were selected for survival in a seedling disease nursery, and a dozen morphological mutants rescued from the East Lansing seed archives.

The primary goal is to develop Recombinant Inbred Lines (RILs) from representatives from each of these hybrids from F_1 plants that have shown good field vigor as well as high seed yield. We use a rapid cycling strategy to advance 1.5 generations per year (e.g. growth in small, deep pots for six weeks, then 12 weeks of vernalization, followed by placing a bag over each small plant to enforce inbreeding, yielding 5 to 50 seeds per plant) and will obtain F_6 seed by single-seed-decent within four years. At least 50 RIL families, each with at least 100 individuals, representing the diversity of beet germplasm currently among experimental hybrids described above will be targeted for synthesis. In 2002 using this system, one family

has been advanced to the F_5, two other families have been advanced to the F_4, 27 other families are being advanced to the F_3, and 22 are being advanced to the F_2. With additional F_1's, the final result will be a set of at least 5,000 inbred lines covering the major agronomic traits to be released to the National Genetic Resources System (i.e. GRIN) for general distribution. Further, each of the 5,000 inbred lines deposited will be marked with molecular genetic tags, at a minimum with 100 mapped AFLP loci per population. These populations will be an invaluable resource for beet geneticists and others. It should be noted that few inbred sugar beets currently exist, and molecular genetic analyses are hampered by the high heterozygosity (>45% on average), which leads to uncertainty assigning heritability estimates for specific traits.

Genetic analyses in sugar beet suffer from its breeding system, which is governed by self-incompatibility that prevents routine selfing and highly transportable pollen (e.g. the slightest breeze) which increases risks of genetic contamination in controlled crosses. Few inbred lines have been constructed. Ones available have been based on a dominant self-fertility gene (or allele). Creating hybrids in Beta is problematic since flowers are slightly protandrous, each flower bears a single ovary, and mechanical disturbance of the flower often results in premature abscission. Therefore, the seed parent for most of the RI populations to be developed has been male sterile (controlled by a single recessive nuclear-encoded allele) in a population fixed for the self-fertility trait. In this manner hybrids are created with ease by bagging a pollen donor with a male-sterile plant, the hybrids are self-fertile and can be selected for expression of agronomic performance in the field or greenhouse. Copious seed production from F_1 hybrids for F_2 populations is assured if mother roots are sufficiently large. The downside is that 25 percent of the F_2 plants will be male-sterile, and lost from subsequent RI generations. This deficiency is being corrected with the recent development of a cytoplasmic male-sterile, self-fertile genotype in future work. It should be noted that development of RI populations is expected to be routine in the future, at least for the East Lansing location. The final requirements for the seed parent, in the case of East Lansing, was that it needed to be generally susceptible to the range of diseases prevalent in the Great Lakes region as well as have reasonable vigor and yield in Great Lakes growing areas in the absence of disease. With few exceptions, all RI populations have been developed using the USDA-ARS Salinas CA line C869 as the seed parent, since it was the only germplasm available satisfying all criteria above. The two exceptions to date have been using an inbred sugar beet (7S) hand crossed with an inbred red beet (W357B) for purposes of developing an unbiased genetic map devoid of segregation distortion around the nuclear male-sterility locus, and a cross using male-fertile C869 segregant as the pollen parent on a traditional East Lansing CMS parent (EL45). It should also be noted that from the perspective of the Western germplasm pool, most RI populations will be developed from a single germplasm with >4,000 potential individuals at the end of the process.

The pollinators used to date vary widely, and the rationale has been to capture the allelic diversity most relevant to expanding the relatively narrow germplasm base of sugar beet. That is, the necessity will be to introgress novel sources of disease resistance, stress tolerance, and agronomic traits from wild beet (where perhaps allelic diversity is 10-fold higher than in sugar beet) and return to acceptable agronomic performance in a reasonable period of time. For this to be accomplished, a definition of the alleles that are most important to the use of beets for efficient sucrose yield is prerequisite. It is assumed that crop types within Beta vulgaris are fixed for alleles that determine their respective phenotypes (e.g. red table beet,

fodder beet, and Swiss chard), therefore only single RI populations are being developed for these types. A number of *B. vulgaris* spp. *maritima* accessions are also being used as pollinators to develop expectations regarding the expansion of allelic diversity. One example is that restricted recombination is seen in all sugar beet genetic maps to date, and a question to be addressed is if crosses with more distant materials also show reduced recombination, and if not can this character be introgressed into sugar beet. Another example is to specifically fix a potentially new allele for Aphanomyces seedling disease resistance from PI540625, an accession that has other potential for resistance to beet viruses as well as Polymyxa betae, the vector for the rhizomania virus. A third example is four other PI's that showed high seedling survival in a seedling disease nursery in Saginaw MI, and each of these has a unique combination of morphological phenotypes (e.g. root shape) that will make preliminary analyses of root genetics possible. Additional variants may be discovered during the inbreeding process that could be useful agronomically, such as an indeterminate flowering habit, however these results are unpredictable.

The largest set of RI populations target genetic analyses of specific East Lansing germplasm resistances, the sucrose accumulation trait, and smooth-root. The basic strategy has been to include a single C869 ms plant within a seed increase plot of the desired pollinator germplasm, such that the ms has the opportunity to acquire all of the alleles in the pollinator population. Up to four RI populations for each of these are being developed. It is generally assumed that their specific traits are fixed in these populations, but preliminary testing for Rhizoctonia resistance showed otherwise. Thus, we must consider the germplasm to be enriched for the relevant allele frequencies. Further, we have to consider evaluating whether at least one of the relevant alleles has been captured in the hybrid, and in most cases this is more resource-intensive than simply selfing the population to homozygosity. Hybrids have been grown under selection (e.g. disease nurseries) to identify the most highly developed phenotypes, and these individuals have been used to self-pollinate to generate F2 populations. Due to the breeding structure of beet improvement, most if not all disease resistance traits behave in a dominant fashion. Thus at the phenotypic level we have a reasonable assurance that at least one allele has been captured for the RI populations, however adequate disease evaluation requires multi-year, multi-location testing. For genetic analyses, it is impractical to rely on the behavior of the hybrids themselves and it is also impractical to rely on single plant evaluations in the F2 for QTL analyses. Progeny testing is possible, however the transient nature of these F3 populations precludes large-scale field trials. Two or three generations of further inbreeding solves these problems to some extent, thus the decision was made to pursue RI populations. It should be noted that heterozygosity introduces an additional source of experimental uncertainty in genetic analyses beyond that influenced by environment, and for this reason beet geneticists and breeders have sought to limit the statistical uncertainty associated with genetic heterozygosity either through anther-culture derived inbreds or by clonal propagation of elite genotypes. All of these methods have drawbacks, however the RI population approach has not been attempted to date and it appears to offer an advantage of recovering a diverse array of adapted genotypes for further breeding and molecular analyses.

The decision to attempt more populations with fewer individuals reflects the lower probability of recovering the positive donor alleles from a heterozygous self-incompatible parental population in a single fertile F_1 hybrid as the primary source of one RI population, as discussed above. More populations developed from the same cross would likely reveal more segregating loci related to trait genetics than would a narrower focus on a few larger

populations, thus we have geared towards capturing the maximum amount of allelic diversity segregating in a slightly larger than practical number of segregating populations. Any set of RI populations developed is unlikely to capture all allelic diversity needed for formal genetic investigations in these early proof-of-concept investigations. The intent here is to demonstrate that inbreeding can be accomplished and that inbreeding depression, segregation distortion, recessive lethality, and other Mendelian genetic masking phenomenon can be eliminated prior to the development of larger populations. The choice of parents continues to evolve as more and better information becomes available from on-going activities. An initial set of 37 RI populations has been started, and as of 3/10/2003 the breakdown is given below. Additional populations including nematode resistant materials, curly top resistant materials, and root maggot resistant materials will fulfill the goal of 50 RI populations.

Description of specific populations as of 3/10/2003:

Crop Type:

7S x Red: This population was originally intended for a foundation genetic map where both parents were inbred and thus purged of deleterious alleles perhaps causing segregation distortion. In retrospect, the 7S parent contributed negative phenotypes of naked seed (e.g. little or no pericarp tissue) and resulting seed shatter. This population appears to segregate for vernalization / devernalization response since half the population consistently fails to bolt upon the first vernalization attempt. Current status: 140 F4 plants (F5 seed obtained), 136 F3 plants (F4 seed production in progress).

C869 x Red beet W357B: This population has been used extensive for the past two years to examine the inheritance of sucrose. The red beet parent is a public germplasm release used widely in commercial red beet hybrids, and is self-fertile with ca. 8% sucrose content at field harvest. The female parent is ca. 15% sucrose at harvest. Field and greenhouse trials on F3 and F2 populations, respectively, showed no difference in sucrose expressed as a percent of dry matter and only one locus was supported with QTL analyses with sucrose expressed as percent fresh weight. Little evidence of restricted recombination (e.g. clustering of markers) was obtained using AFLPs on the F2 population. Current status: 70 unselected and 100 field selected F3 plants.

C869 x Indian Table beet (PI163182): This population is being developed as a potential source of field resistance to seedling diseases from a selection plot at the Bean and Beet Farm in Saginaw MI in 1999 where it performed comparably in disease and non-disease nurseries, and also as a source of allelic variation not present in sugar beet germplasm. Current status: 200 F2 plants in each of 2 populations.

C869 x Fodder: This population is being developed to examine inheritance of animal fodder crop use type. Current status: 200 F2 plants in each of 2 populations.

C869 x Chard: This population is being developed to examine inheritance of leaf crop use type. Current status: 200 F2 plants in each of 2 populations.

Agronomic evaluation:

C869 x SP6822: This population was developed to examine inheritance of agronomic traits and Aphanomyces resistance. SP6822 is the pollinator for USH20, the hybrid discussed in Objective 3 with high emergence potential, that was widely grown for sucrose in Michigan from 1975 to 1985. The seed parent is similar to EL45cms listed below. Current status: 200

F3 plants (in each of 4 populations).

C869 x PI540625: This population was developed to examine two aspects of expanding the germplasm base of sugar beet. The first is to introgress a potentially novel genetic source of resistance to seedling damping-off by Aphanomyces cochlioides. The second is to examine the phenomenon of restricted recombination in sugar beets. The pollen parent is a wild *Beta vulgaris* spp. *maritima* collected from the north coast of France, with reported high levels of Aphanomyces resistance (via the GRIN system). Work over the past three years has confirmed at least one locus contributing a high level of resistance to Aphanomyces infection in seedlings two weeks of age. Field trials in 2002 also showed a high level of resistance to the chronic disease phase. Recombination as assessed with AFLPs in the F2 appears less restricted in this population than in other reported sugar beet molecular maps. Current status: 80 F3 plants plus 10 other F2 populations not yet tested.

C869 x EL50: This population is being developed to examine inheritance of leaf spot resistance caused by Cercospora beticola. EL50 is among the most resistant germplasm available and is well adapted to Great Lakes growing conditions. Resistance has been described as complex (5 – 8 QTLs) and is markedly influenced by environment, and availability of RI populations segregating of resistance will be invaluable. Current status: 200 F2 plants in each of 4 populations.

C869 x EL48: This population is being developed to examine the inheritance of elite 'traditional' East Lansing seed parent germplasm release materials. EL48 is monogerm, self-sterile, and O-type, with moderate sucrose concentrations (ca. 15%), and high resistance to Aphanomyces as compared with the USDA-ARS Salt Lake City UT germplasm from which it is derived. It has low heterozygosity and a narrow germplasm base. Current status: 200 F2 plants in each of 2 populations.

C869 x L19/2: This population is being developed to examine inheritance of high sucrose content from L19/2 (ca. 20%). This Z-type germplasm was reselected from L19 for adequate performance in Great lakes growing regions, however is extremely susceptible to the range of disease pressures in these areas. Current status: 200 F2 plants in each of 2 populations.

C869 x C869: This population is being developed as a control population for field comparisons with other RI populations. Current status: 200 F2 plants.

C869 x SR94: This population is being developed to examine inheritance of the smooth-root trait. SR94 also has near commercial levels of sucrose, reasonable yield potential, and good Aphanomyces and Cercospora resistance. 200 F2 plants in each of 2 populations.

C869 x EL51: This population is being developed to examine resistance to Rhizoctonia crown and root rot caused by Rhizoctonia solani. EL51 is among the most Rhizoctonia resistant germplasm, with parentage from USDA-ARS Ft. Collins releases as well as independent USDA-ARS East Lansing selections. This and another population was screened in the greenhouse (J. Weiland, USDA-ARS, Fargo ND cooperating) and this population was the more resistant. Current status: 200 F2 plants.

Each of the following hybrids, 10 plants of each, are being selfed to generate enough F2 seed for RI population development: C869 x PI169025, PI169030, PI357360, and PI5990770 (four separate population from seedling disease nursery selections); C869 x SP85303 (Phytophthora resistance); C869 x [SP6822 x Z430] (complex hybrid); C869 x GW359

(original Cercospora resistance source, highly heterozygous); C869 x SP657-0 (O-type, Aphanomyces resistant); C869 x KleinE (likely progenitor of US germplasm releases); C869 x [Sugar x Fodder] (selected for use of beets as potential bio-fuel); C869 x HiGerm Group (high emergence field selected populations from poorly stored seedlots); EL45cms x C869 (reciprocal cross, potential development of East Lansing adapted self-fertile O-type); and C869 x USH20 (high emerging cultivar).

Hydrogen Peroxide Concentration in Stress Germinated Sugar Beet Seeds

Shiranee Gunasekera, Azeza Bughrara, Susan Myers, J. Mitchell McGrath
Michigan State University and USDA-ARS, East Lansing MI

Percentage of germination and seedling emergence determine potential harvest of sugar beet crops. For commercially planted seed, laboratory germination >92% is required, but emergence is often 50-60% under optimal field environments. Field emergence of sugar beet is a major concern for growers, and economically impacts the sugar beet industry. Previous reports have indicated that the abiotic factors largely contribute for poor germination and emergence in sugar beet. McGrath et al. (2000) stated that the varieties differ in field emergence, indicating a genetic basis for this trait.

Hydrogen peroxide (H_2O_2) is generated by a number of reactions in plants (Bolwell and Wojtaszek, 1997) and several reports indicate that it has a beneficial effect on seed germination in a number of crops including sugar beet (Chein and Lin, 1974; Hsiao and Quick, 1984; McGrath et al., 2000). The objective of this study was to develop a rapid test to examine significant differences between varieties with respect to the amount of H_2O_2 evolved during germination. Variety US H20, which exhibits superior germination under both artificial stress (laboratory) and actual field conditions, and ACH 185, which has rather poor germination, were selected for this preliminary study.

Materials and Methods

Seeds of US H20 (Seed lot WC990379) and ACH185 (Seed lot WC990382), both grown in Oregon under commercial seed increase environments, were randomly selected. Fifty seeds from each variety were soaked in 100 ml of distilled water at room temperature shaking in an incubator at 150 rpm. Seeds were soaked for different time intervals so that we could obtain seeds soaked ranging from 3 hrs to 4 days. The seeds soaked for more than 24 hrs were rinsed every day and replaced with fresh distilled water.

Fruits after soaking were de-capped with a dental tool, the embryos removed, and a single true seed was placed in a micro titer plate well. 60 μl of sterile distilled water added to each well, and seeds were crushed by gently striking a 96-pin lid with a rubber mallet. Plates were centrifuged for 20 min at 4,000 rpm at 4°C. 50 μl supernatant was transferred to a new plate and 50 μl of reaction mix (Amplex Red reagent / HRP working solution) was added to each micro plate well containing standards, controls and samples, and incubated at 25°C for 30 min in the dark. Fluorescence was measured at 590 nm and H_2O_2 concentration was calculated relative to a standard curve included in each plate, in three replicates. The Amplex Red Hydrogen Peroxide / Peroxidase Assay Kit (A-22188) was supplied by Molecular Probes Inc. and measured using a plate reader in luminescence mode (Perkin Elmer Victor V). Six seeds per replicate were tested.

Results

Screening large quantities of germplasm for production of hydrogen peroxide evolution during germination is required to evaluate the contribution of this mechanism to improved emergence and stand establishment. Previous results have shown that evolution of hydrogen peroxide is correlated with expression of a Germin-like protein with putative oxalate oxidase activity, and this activity only occurs in the high emerging US H20 under laboratory stress at room temperature. A rapid test is needed to screen additional germplasm, and results from this new procedure were consistent with previous results (Figure 1). Further, this new procedure allows evaluation of the timing of hydrogen peroxide evolution. Future work will be to carry out a germplasm survey with different sugar beet lines to find if there is a correlation between H_2O_2 concentration in germination seeds and the germination and emergence percentage in the field.

Figure 1: Evolution of hydrogen peroxide in seeds soaked in water for various times.
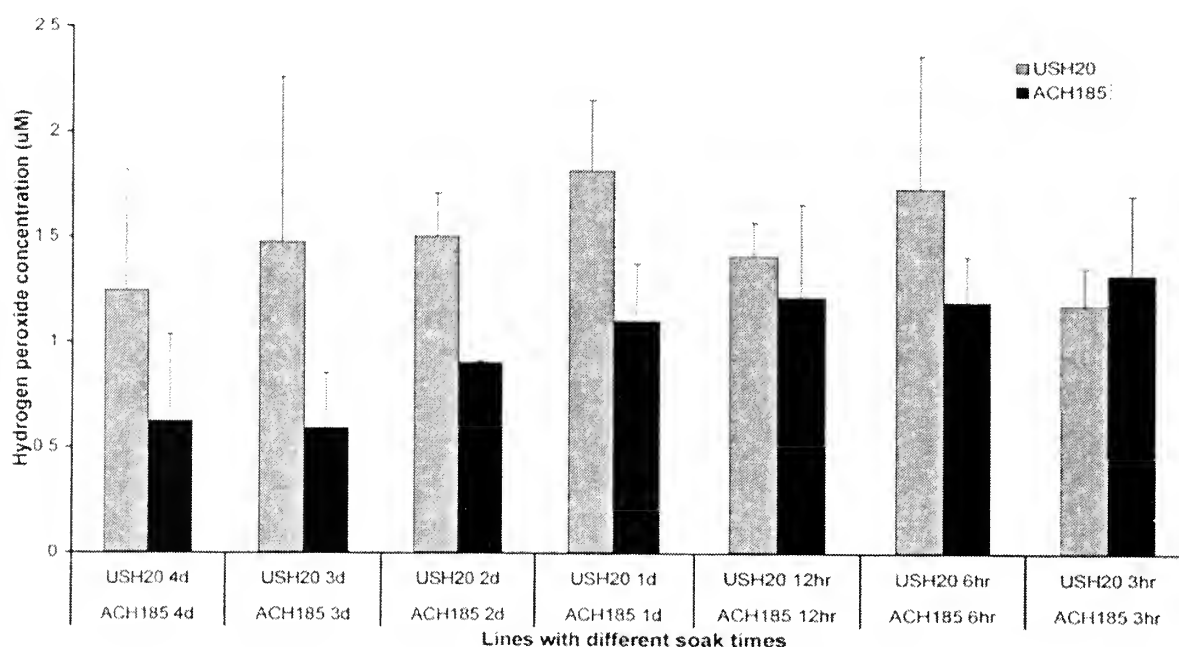
References

Bolwell GP, Wojtaszek P (1997) Mechanisms for the generation of reactive oxygen species in plant defense – a broad perspective. Physiol Mol Plant Pathology 51: 347-366.

Chein CT, Lin TP (1974) Mechanism of hydrogen peroxide in improving the germination of *Cinnamomum camphora* seed. Seed Science and Technology 22: 231-236.

Hsiao AI, Quick WA (1984) Actions of Sodium hypochlorite on seed dormancy and germination of wild oats (*Avena fatua*). Weed Research 24: 411-419.

McGrath JM, Derrico CA, Morales M, Copeland LO, Christenson DR (2000) Germination of sugar beet (*Beta vulgaris* L.) seed submerged in hydrogen peroxide and water as a means to discriminate cultivar and seedlot vigor. Seed Science and Technology 28: 607-620.

SUGAR BEET RESEARCH

2002 REPORT

Section E

Molecular Plant Pathology Laboratory
Agricultural Research Service
United States Department of Agriculture
Beltsville, Maryland

Dr. Ann C. Smigocki, Research Geneticist
Dr. David Kuykendall, Plant Pathologist
Dr. Chris Wozniak, Visiting Scientist

CONTENTS

Gene Transfer to Improve Sucrose Yields from Sugar Beet Taproots

BSDF Project 810

Ann C. Smigocki

Introduction

We genetically engineered sugar beet to produce increased levels of the plant growth hormone cytokinin in the taproots in order to evaluate the effect of cytokinin on rate of cell division, vascular ring development, and sucrose accumulation in the taproots (Ivic et al., 2001c; Snyder et al., 1999). Initiation of cambia and rapid cell expansion and division have been reported to be correlated with changes in hormonal concentrations in the developing taproot (Elliot and Weston, 1993). In addition, cytokinins have been identified as having functional significance in the control of assimilate movement in plants, particularly by altering phloem unloading, sink initiation, and sink strength and capacity. We also correlated elevated cytokinin levels with enhanced insect resistance in plants (Smigocki et al., 1993) and demonstrated that cytokinin-induced insecticidal compounds killed sugar beet root maggot larvae, one of the most devastating insect pests of sugar beet (Smigocki et al., 2003).

To increase the endogenous cytokinin concentrations in the taproot, we fused the bacterial cytokinin biosynthesis gene, *ipt*, to a tuber-specific promoter from the patatin gene of potato. We successfully regenerated three transgenic shoots for analysis of cytokinin effects on taproot development, sucrose accumulation and insect resistance (Ivic et al., 2001b). Analysis of sucrose concentrations in transgenic plants revealed that the leaf sucrose levels were comparable to those in normal controls. The taproots of transgenic plants had low sucrose concentrations in comparison to the controls because the taproots did not develop normally and their weight was reduced by over 90%. In order to evaluate the role of cytokinins in photosynthate accumulation,

taproot development and insect resistance in sugar beet, a larger number of independently derived transgenic plants are needed. The regeneration of a relatively large number of transgenic plants is dependent on the availability of an efficient transformation method that currently is lacking for sugar beet.

Biotechnological approaches for sugar beet improvement have been hampered primarily by the lack of a reliable transformation method and low transformation frequencies. The particle bombardment method has proven superior for achieving truly genotype-independent transformation in agronomically important crops. However, our attempts to transform commercially important sugar beet lines using particle bombardment of hypocotyl callus (Snyder et al., 1999) that was developed with a highly regenerative tissue culture clone REL-1 (Saunders, 1998) were unsuccessful. In addition, this method entails several lengthy and labor-intensive steps for plant material preparation, including a seed germination step that is often plagued by high levels of microbial contamination.

Progress report

Results and Discussion

As a first step for developing a reliable transformation protocol for commercially important sugar beet lines, we optimized the production of highly embryogenic cells for use with the particle bombardment gene transfer method. Using leaves of greenhouse-grown sugar beet breeding lines (FC 607, C69, C78, C76895, 7911-4-10 and Z731), we determined which plants consistently produced highly regenerative leaf callus (Ivic et al., 2001b). All tissues were cultured on MS mineral salts containing nicotinic acid (0.5 mg/l), thiamin-HCl (1 mg/l), pyridoxin-HCl (0.5 mg/l), myo-inositol (100 mg/l), MES (500 mg/l), sucrose (3%), and plant growth regulators and other supplements as indicated in Table 1. Although both somatic

embryos and adventitious shoots were produced on all of the tested media, the greatest number of shoots regenerated on B1T1 medium. Up to 150 shoots per plate regenerated after 10 weeks of culture.

Table 1. Composition of the culture media

Medium	Growth regulators (mg/l)		
	BAP	TIBA	ABA
B1	1	-	-
B1T1	1	1	-
B1A2	1	-	2
B1A0.2	1	-	0.2
B1A0.02	1	-	0.02

Breeding line FC607 produced regenerative callus equal in quantity and quality to the REL-1 clone. More than 75% of the leaf discs formed friable callus with more than half regenerating an average of 10 shoots per leaf disc. Preparation of suspension cultures from the leaf disc callus generated large quantities of embryogenic callus for use with the particle bombardment transformation method (Ivic and Smigocki, 2001a). The advantages of using leaf discs instead of hypocotyls or cotyledons for production of the callus include minimal contamination rates in tissue culture, ease of handling of the plant material, and relatively large quantities of callus that can be generated in a short period of time.

To optimize the transformation protocol, we tested a range of selection conditions and two selection agents, kanamycin and paromomycin as one of the reasons for the low

regeneration potential of transformed sugar beet tissues might be due to the toxic effect of kanamycin (Ivic and Smigocki, 2003).

Leaf discs were excised from young leaves of greenhouse-grown FC607 plants and cultured on B1 medium. Friable, embryogenic callus was collected after 5-6 weeks and grown for 2 weeks in liquid B1 medium. Cell suspensions were sieved, spread as a thin layer on filter paper, and placed on T1B1medium a day before particle bombardment. Cells were bombarded with gold particles coated with plasmid DNA. Transformation vectors carried the reporter gene *uidA* (gus) gene fused to either the osmotin (osm) or proteinase inhibitor II (pin2) gene promoter. The *npt II* gene under the control of the nos promoter was included as a selectable marker gene for kanamycin resistance. After 2 to 12 days, cells were transferred to selection medium containing 100 mg/l kanamycin or 25 mg/l paromomycin.

Transient GUS expression 2 days after bombardment ranged from 900 to 3000 blue units per bombarded plate but expression decreased significantly during the initial 14 days of culture. Stably transformed GUS (+) calli were obtained as early as 3 weeks following bombardment at a frequency of 0.25 - 9 calli per bombarded plate (Table 2). Higher number of transformed calli was obtained when cells were passed through sieves with opening size 850 μm vs 425 μm.

Table 2.

			Number GUS (+) calli per plate			
Selection agent	Delayed selection	Length of selection	Osm-GUS		Pin2-GUS	
			425 μm	850 μm	425 μm	850 μm
Kanamycin	No	3 w	0.00	-	0.00	1.75
	No	5 w	0.00	-	0.00	9.00
	No	Continuous	0.50	-	0.00	0.25
Paromomycin	No	Continuous	-	0.00	-	-
	5 days	Continuous	-	0.36	-	-
	10 days	Continuous	-	0.40	-	-

Since the GUS test is destructive, it prevented the recovery of transformed shoots from GUS (+) embryos and calli. A different marker gene such as the one coding for the green fluorescence protein (GFP) may be a better nondestructive alternative for detection of transformed sugar beet tissues and lead to the recovery of stably transformed plants.

References

1. Elliot, M.C. and Weston G.D. 1993. Biology and physiology of the sugar-beet plant. In: Cooke DA, Scott RK (eds) The Sugar Beet Crop: Science into practice. Chapman and Hall, London, pp 37-66.

2. Ivic, S. and A. Smigocki. 2003. Transformation of sugar beet cells suspensions cultures. In Vitro Cell. Develop. Biol. 39: in press.

3. Ivic, S. and A. Smigocki. 2001a. Evaluation of the biolistic transformation method for commercially important sugarbeet breeding lines. Proc. Am. Soc. Sugar Beet Technologists, p. 207-213.

4. Ivic, S., J. Saunders and A. Smigocki. 2001b. Leaf callus from sugarbeet breeding lines for biolistic transformation, Proc. Am. Soc. Sugar Beet Technologists p. 214-216.

5. Ivic, S.D., R.C. Sicher and A.C. Smigocki. 2001c. Growth habit and sugar accumulation in sugarbeet (*Beta vulgaris* L.) transformed with a cytokinin biosynthesis gene. Plant Cell Rep. 20:770-773.

6. Saunders, J.W. 1998. Registration of REL-1 and REL-2 sugarbeet germplasms for tissue culture genetic manipulations. Crop Sci. 38: 901-902.

7. Smigocki, A.C., J.W. Neal, I.J. McCanna and L. Douglass. 1993. Cytokinin-mediated insect resistance in *Nicotiana* plants transformed with the *ipt* gene. Plant Mol. Biol. 23:325-335.

8. Smigocki, A.C., L. G. Campbell and C.A. Wozniak. 2003. Leaf extracts from cytokinin-overproducing transgenic plants are lethal to sugar beet root maggot (*Tetanops myopaeformis*) larvae. J. Sugar Beet Res. (submitted 1/03)

9. Snyder, G.W., J. C. Ingersoll, A.C. Smigocki and L.D. Owens. 1999. Introduction of pathogen-defense genes and a cytokinin biosynthesis gene into sugarbeet (*Beta vulgaris* L.) by *Agrobacterium* or particle bombardment. Plant Cell Rep. 18:829-834.

Engineering sugar beet root maggot resistance with multiple proteinase inhibitor genes

BSDF Project 811

Ann C. Smigocki

Introduction

Disease and insect pest problems have had a significant negative impact on sugar production from sugar beet. The sugar beet root maggot (SBRM), *Tetanops myopaeformis* Roder, is now considered a major pest of sugar beet in the United States and Canada. This Dipteran inflicts yield losses that can range from 10 to 100%. Developing larvae feed on tap and feeder roots throughout the growing season causing damage either by severing the taproots of seedlings or badly scarring the surface of larger roots. Damaged taproots are predisposed to diseases caused by opportunistic pathogens such as *Erwinia carotovora* subsp. *betavsculorum*, *Aphanomyces cochlioides*, and *Rhizoctonia solani*. Granular insecticides are often used to reduce larval populations in sugar beet fields, although control is inconsistent. Crop rotation practices have been ineffective mainly due to the mobility of the adult flies. Existence of several weed species as substitute hosts has hindered population control. The lack of effective control measures that do not rely on broad-spectrum insecticides has hastened the search for environmentally friendly alternative strategies.

Protection of plants from herbivorous insect pests has traditionally relied on conventional breeding programs for incorporation of resistance traits. With the advent of molecular biology, insect resistance genes have been identified, cloned and transferred to heterologous plants to impart disease resistance. Gene transfer technology is an economical and environmentally favorable approach to reduce the usage of toxic chemicals for insect control.

Molecular approaches to enhance disease and insect resistance in sugarbeet have been hampered by a general lack of a reliable gene transfer method, a small pool of well characterized defense genes, and knowledge of sugarbeet defense responses. Our efforts are focused on several approaches geared towards the development of effective strategies for the control of SBRM. One of the approaches involves the manipulation of the production of toxic compounds *in planta*. These compounds are mainly products of secondary metabolic pathways, many of which have been shown to play a role in plant defense responses (Smigocki et al., 2003; Smigocki et al., 1997 and 2000). Another approach involves the characterization of a fungal pathogen, *Syngliocladium tetanopsis*, a recently patented biocontrol fungus (Wozniak, 1999). *S. tetanopsis* is the only known naturally occurring pathogen of SBRM and is capable of inciting an epizootic within SBRM populations, thereby bringing about a reduction in numbers. We have also initiated studies to characterize sugar beet defense response mechanisms. Profiling of genes in resistant sugar beet lines is an approach that will provide useful information for developing new insect control strategies. Another approach of interest is the development of genetically modified sugar beet that express proteinase inhibitor genes to specifically target midgut proteases of SBRM larvae. By blocking the major classes of digestive proteases in actively feeding maggots, the assimilation of nutrients from ingested foods would be inhibited and thus thwart the normal growth and development of the insect (Wilhite et al., 2000).

Progress Report

One of the objectives is to develop transgenic sugar beet that are resistant to the root maggot using proteinase inhibitor genes that specifically target the digestive enzymes of the maggot. In order to devise a rational control strategy based on the use of proteinase inhibitors, it is necessary to first determine the specific digestive enzymes of the targeted pest since

significant variations exist in the types and properties of digestive enzymes utilized by insects. We characterized the major midgut proteases in feeding second instars collected from infested fields in Minnesota (Wilhite et al., 2000). Midgut extracts were prepared within 48 hours from time of collection and analyzed for protease activity. Two components of the activity were evident at an acidic pH with an optimum of 2.5 or lower, and another had a pH optimum of approximately 8.5. Low-molecular weight biochemical inhibitors that target the major mechanistic classes of insect digestive endoproteinases were used to determine the nature of the proteases in the SBRM extract. We demonstrated that Pepstatin A with preferential specificity toward aspartyl proteases was by far the most effective inhibitor at an acidic pH (84% inhibition). PMSF which targets serine proteases reduced proteolysis in SBRM extracts by 50%. E-64, which has high potency toward virtually all known cysteine proteinases, had a minor inhibitory activity of about 7%. We also tested the effect of several plant-derived PIs on the proteolytic activity (Table 3). Squash aspartyl proteinase inhibitor blocked virtually all the proteolytic activity, confirming the importance of the aspartyl class at acidic pH. Soybean trypsin-chymotrypsin inhibitor (Bowman-Birk I) blocked nearly all proteolysis at pH 8.5, suggesting the presence of trypsin and/or chymotrypsin-like serine proteases in the extract. Similarly, rice oryzacystatin I that targets cysteine proteases (Samac and Smigocki, 2003) blocked approximately 20% of the activity.

In vitro inhibition of midgut activity with a single proteinase inhibitor will not necessarily inhibit digestion as some insects seem to be physiologically capable of avoiding toxicity due to protease inhibitor ingestion by secreting "inhibitor-insensitive" enzymes and by the proteolysis of proteinase inhibitors by non-target digestive proteases. We propose to combine inhibitors effective against all the major proteolytic activities of the root maggot as a strategy for enhanced

stability and additive effect on proteolytic inhibition. We identified proteinase inhibitor genes with specificity for the aspartyl, serine, and cysteine class of proteases in SBRM midguts that will be introduced into sugar beet for evaluation of their effect on SBRM larvae.

Taproot-specific expression of genes coding for the aspartyl, serine and cysteine proteinase inhibitors would target the production of the inhibitors to the site of insect attack. We successfully developed a root maggot feeding bioassay using sugar beet seedlings to test the effect of the proteinase inhibitors *in vitro* and *in vivo* and for subsequent screening of transgenic plants (Smigocki and Boetel, unpublished). In addition, using this bioassay, we generated root maggot infested plant tissues of both resistant and susceptible lines. These tissues were used to prepare a taproot specific cDNA library for cloning of taproot-specific genes as well as genes associated with root maggot resistance. The corresponding promoters for the taproot-specific genes will be characterized and will be of great benefit for targeting of beneficial genes, including the proteinase inhibitors, to the taproot.

References

1. SAMAC, D. A. & SMIGOCKI, A. C.: Expression of oryzacystatin I and oryzacystatin II in alfalfa increases resistance to the root-lesion nematode (*Pratylenchus penetans*). *Phytopathology* 91: in press, 2003.

2. SMIGOCKI, A. C., CAMPBELL, L. G. & WOZNIAK, C. A.: Leaf extracts from cytokinin-overproducing transgenic plants kill sugarbeet root maggot (*Tetanops myopaeformis*) larvae. *J. Sugar Beet Res.*, submitted, 2003.

3. SMIGOCKI, A. C., HEU, S. & BUTA, G.: Analysis of insecticidal activity in transgenic plants carrying the ipt plant growth hormone gene. *ACTA Physiol. Plant* 22:295-299, 2000.

4. SMIGOCKI, A. C., HEU, S., MCCANNA, I., WOZNIAK, C. A. & BUTA, G.: Insecticidal compounds induced by regulated overproduction of cytokinins in transgenic plants. In *Advances in Insect Control, The Role of Transgenic Plants*, edited by N. Carozzi and M. Koziel. Bristol: Taylor and Francis, Ltd., 1997.

5. WILHITE, S. E., ELDEN, T. C., PUIZDAR, V., ARMSTRONG, S. & SMIGOCKI, A.C.: Inhibition of aspartyl and serine proteinases in the midgut of sugarbeet root maggot with proteinase inhibitors. *Entomol exp appl.* 2000.

6. WOZNIAK, C. A.: Novel fungal pathogen for biocontrol of the sugarbeet root maggot. USA Patent #5,955,071, 1999.

Improving Resistance to *Cercospora*-induced Leafspot Disease in Sugar Beet Using Biotechnology

Kuykendall, L.D. and T.M. Stockett.
Molecular Plant Pathology Laboratory, Plant Sciences Institute, Beltsville Agricultural Research Center, USDA/ARS, Beltsville, MD 20705

Introduction

Our laboratory conducts bioengineering research on sugar beets in order to safely control crop losses due to fungal disease. Biotechnology is needed for the control of leaf spot disease in sugar beets since germplasm improvement via screening and conventional breeding methods has yielded only moderate resistance that is multigenic and thus not readily incorporated into agronomically elite germplasm.

Sugar beet crops survive *Cercospora* outbreaks but both tonnage and sucrose percentages are significantly diminished. Development of *Cercospora* leafspot disease-resistant germplasm could increase crop profitability 25% or more overall. Although spraying with fungicides is used to combat predicted Cercospora foliar disease outbreaks, this environmentally unfriendly practice is also known to select for variants or spontaneous mutants possessing fungicide(s) resistance. Fungicide-tolerant strains of *Cercospora* diminish the effectiveness of subsequent applications of chemical fungicides.

In 1999, Snyder, Ingersol, Smigocki & Owens reported the development of transgenic sugar beets carrying genes encoding bacterial cytokinin and plant pathogen defense-related proteins under transcriptional control of stress or wound inducible promoters. These novel plant genotypes were examined for their ability to inhibit *Cercospora* (Kuykendall and Smigocki, 1999). Two promising transgenic sugar beet genotypes, OOT and *osm*PrS, with antimicrobials under the control of the strong osmotin promoter, were examined in the growth chamber for *Cercospora* leafspot resistance (Kuykendall, 2001). Unfortunately both transgenics were significantly more susceptible to leaf spot disease than their parental germplasm; but a useful disease assay under controlled conditions was developed.

The new concept that a pathogen's gene encoding a toxin pump can confer resistance in the host originates from a recent research finding at North Carolina State University that the *cfp* gene, which specifies a cercosporin export protein, produces transgenic tobacco plants highly resistant to *Cercospora* infection (R.G. Upchurch, personal communication). In this BSDF annual report, we describe experimental results using Polymerase Chain Reaction (PCR) to demonstrate the successful construction of a *cfp*-carrying transgenic sugar beet. The success of this particular project has been largely possible due to our prior improvement in sugar beet regeneration (Saunders et al., 2001). Adventitious shoots obtained without a callus intermediate was herein applied to genetic transformation.

Materials and Methods

Seed of the C69 breeding line, developed by Dr. Bob Lewellen at Salinas, CA, and of the Rel-1 biotechnology clone, developed by the late Dr. Joe Saunders, ARS/MSU, were used as starting materials. The *cfp* gene from *Cercospora* was supplied to us by Dr.

R. G. Upchurch, ARS/NCSU, Raleigh, North Carolina. Plasmid pX contained the full length cDNA clone of *cfp* under the transcriptional control of the S35 promoter contained in pBIN19 (Clontek). Plasmid DNA was electroporated into *Rhizobium radiobacter* EHA105, and transformants were selected on LB agar medium containing 75µg/µl kanamycin sulphate.

Sugar beet seeds were surface-sterilized using a solution containing 15% commercial bleach (5.25% sodium hypochlorite) and 0.01% SDS. Two twenty minute washes were performed, then the seeds were rinsed with sterile water 5 times and they were allowed to dry in a laminar flow hood. Rel1 and C69 seeds were individually germinated on petite 1/20 TSA-containing plates in the dark. After 14 days, approximately 70% germination and 25% contamination were typically observed. Cotyledons were excised from seedlings 2-3 days post germination and were aseptically transferred to a modified MS medium (Murashige and Skoog base with the Gamborg's vitamins; 0.5 g/l of MES buffer; 30.0 g/l of sucrose; pH 5.8, adjusted with KOH and solidified with 5.0g/l of Agargel) with 1.0 mg/l of 6-benzylaminopurine (BAP). Cotyledons were wounded either by cutting with a scalpel or piercing and then were infected with strain EHA105 carrying pX. Bacteria were grown from freezer stocks as 3 ml liquid cultures grown at 25°C for 1-2 days on a rotary shaker to high viable cell densities, greater than 10^9 CFU/ml. Cotton swabs dipped in strain EHA105 (pX) were used to transfer the plant-conjugative bacteria onto the surface of the freshly wounded cotyledons. Inoculated cotyledons were incubated in 30°C dark conditions for about 3 days, to allow time for multiplication and interkingdom conjugation. Green, still viable cotyledons were then transferred to selective medium.

Selective plates were placed in low light and room temperature conditions earlier determined (Saunders et al., 2001) to produce adventitious shoot regeneration without an intermediate of hormone-independent callus.
Cotyledons were transferred to medium containing 0.3 mg/l of BAP, 100 mg/l cefotaxime and 75 mg/l of kanamycin sulphate and then exposed to light (3200 Lux) and room temperature, about 24°C. Those with shoots forming without evident bacterial growth were transferred to fresh medium containing the same BAP and antibiotic concentrations, and then allowed sufficient incubation time to grow large enough to be propagated *in vitro*. Such shoot cultures were maintained, and after at least 4 or 5 transfers, leaf tissue was excised for DNA extraction. Plant leaf tissue was also placed in LB broth and incubated at 37°C to test for growth of any surviving bacteria on the leaf surface. Plant DNeasy™ kits (Qiagen) were used to extract DNA for PCR analysis. Gel electrophoresis of PCR products obtained using *cfp*-specific primers C1 and C2 was performed. PCR products were analyzed by 1% agarose gel electrophoresis stained in ethidium bromide and visualized with uv. Fragment sizes were estimated with reference to a 1kb ladder size standard (New England Biolabs, Beverly, MA). Parental REL-1 plant DNA served as a negative control and plasmid X DNA as a positive control. The sequence of the C1 sense primer (5' to 3') was CCA TCA TCA GCA CAG CAA TCC. The sequence of the C2 antisense primer (3' to 5') was TAC AGC AAC GAC ACG ACC AG.

Results and Discussion
In order to obtain *cfp*-carrying transgenic sugar beets with resistance to *Cercospora* leafspot disease, we treated hundreds of cotyledons of different genotypes

with bacteria bioengineered to transfer desired genes into plants. About 1% regeneration was obtained, and 3 distinct, putative *cfp*–carrying transgenics were obtained, one from Rel-1 and two from C69 germplasm. Gel electrophoresis of PCR products revealed that the Rel1 transformant was verified since it's genomic DNA produced a fragment of the molecular size predicted based on published DNA sequence data, to the nearest hundred basepairs (lane 3) whereas a putative C69 transformant could not be confirmed since it's genomic DNA gave anomalous fragments (lane 6) (Figure 2). The PCR product amplified from the genomic DNA of the Rel-1 transformant is being sequenced. Experiments on infecting new cotyledons are underway. The transgenic clone, termed T7, has been vegetatively propagated to produce twelve mature plants. The successful introduction of the *cfp* gene into sugar beet via transformation could lead to the identification of germplasm with resistance to *Cercospora* leafspot infection. If successful, the resultant germplasm could be used in commercial breeding programs as a source of a single dominant leafspot disease resistance allele.
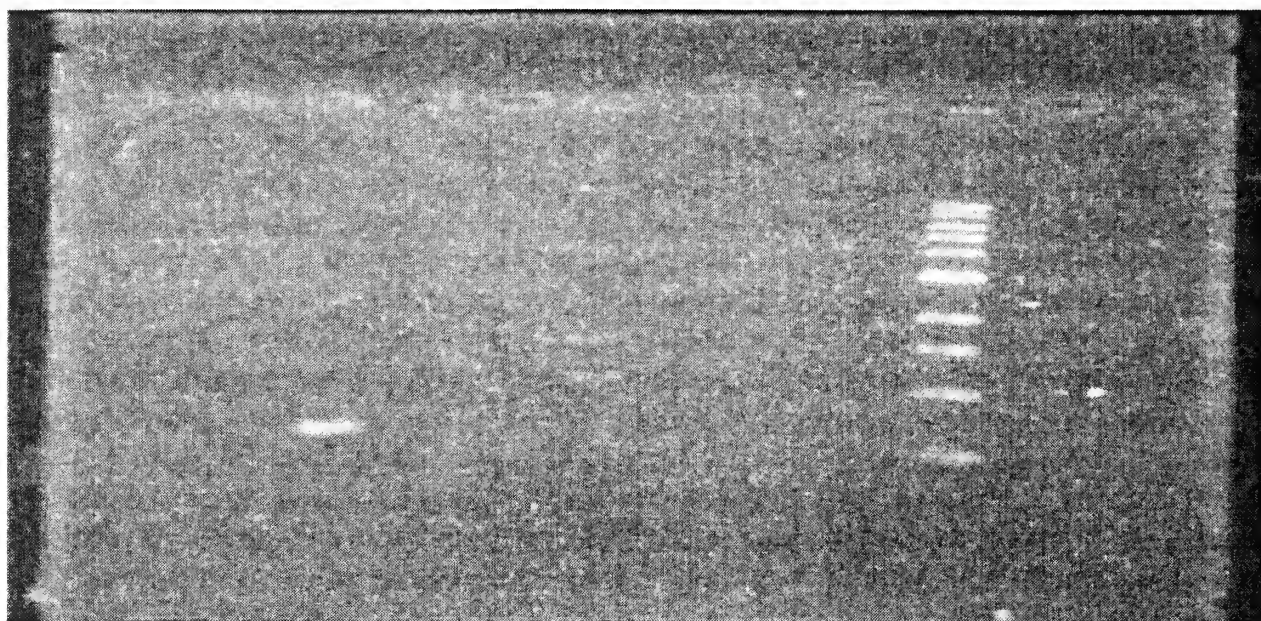
Figure-1. Gel electrophoresis of PCR amplification products. Lane 3 shows an amplification product obtained with the DNA of a Rel-1 transformant. Lane 6 shows products obtained with DNA of a putative C69 transformant, and lane 10, a1 kb ladder.

References

Kuykendall, L.D. and A.C. Smigocki. 1999. *Cercospora beticola* interactions with sugar beet cultures. *Proceedings of the 30 th Biennial Meeting of the American Society of Sugar Beet Technologist, Agriculture Volume* pp.233-235. Beet Sugar Development Foundation, Denver, CO.

Kuykendall, L.D. 2001. Induction of *Cercospora* leaf spot disease on parental and selected transgenic lines carrying antimicrobials: new source of anti-*Cercospora* genes will now be used for bioengineering disease resistance. *Proceedings of the 31st Biennial Meeting of the American Society of Sugar Beet Technologist, Agriculture Volume* pp. 129-132. Beet Sugar Development Foundation, Denver, CO.

Snyder, G.W., J.C. Ingersoll, A.C. Smigocki, and L.D. Owens. 1999. Introduction of pathogen defense genes and a cytokinin biosynthesis gene into sugar beet (*Beta vulgaris* L.) by *Agrobacterium* or particle bombardment. Plant Cell Reports **18**:829-834.

Characterization of a Fungal Pathogen of the Sugarbeet Root Maggot

Chris A. Wozniak

Visiting scientist, USDA/ARS, Molecular Plant Pathology Lab
Beltsville, MD

Ann C. Smigocki

USDA/ARS, Molecular Plant Pathology Lab,
Beltsville, MD

Introduction:

The goal of this project is to further the characterization of a sugarbeet root maggot (SBRM) fungal pathogen, *Syngliocladium tetanopsis*. Since this fungus represents a novel species, the basic biology of the organism is largely unknown. What is known, however, suggests that there is some potential here for the development of a biopesticde for management of the SBRM. As with all biopesticides, the economic aspects of its use and the ability to pass regulatory muster are critical to success.

Work on this organism was initiated at the Red River Valley Agricultural Research Center in Fargo after diseased SBRM were found at several locations within the valley. Cultures of this fungus have been deposited in culture collections at Peoria, IL (ARS-NRRL) and Ithaca, NY (ARSEF; CUP), with the remainder housed at Fargo and Beltsville. A patent was issued by the U.S. Patent and Trademark Office in 1999 covering the use of this fungus for SBRM management.

The same parameters that guide the success of the commercial biopesticides available for a variety of insect species apply to the development of *S. tetanopsis* for root maggot control. Namely, high infectivity (virulence), economics of production, ability to manufacture a viable (stable) formulation, regulatory/safety concerns, and a suitable market all influence the potential utility of this agent. Our previous lab bioassays and field observations indicate that suitable virulence exists within the isolates examined from natural epizootics.

Contacts made through a USDA-ARS website and press release have resulted in a new collaboration with an organic producer and distributor, smallplanetfoods.com. This firm is a marketer of Cascadian Farms and Muir Glen produce, now owned by General Mills. Pest control within the realm of organic agriculture requires a different approach than conventional agriculture in many respects. The use of fungal biopesticides is within the approved organic standards for crop production and potentially even more critical for this market as alternatives are few. The seed corn maggot, also known as the bean seed fly, is problematic in several vegetable crops and is not being effectively managed currently.

Results and Discussion:

The seed corn maggot (SCM), also a dipteran insect (Anthomyiidae), was found to be susceptible to *S. tetanopsis*. These data are based solely on laboratory assays which have not been duplicated in the field as of yet. Infected cadavers of SCM larvae were capable of serving as infective inoculum and diseased SBRM resulted when co-incubated. *S. tetanopsis* was recovered in pure culture from the infected SCM and SBRM and was found to be virulent to either of these species upon reinoculation. Observations of isolates reared on artificial media suggest that this species requires passage through a susceptible host after every three or four subcultures to maintain virulence. This phenomenon is common with both animal and plant pathogens.

While this insect, *Hylema* (*Delia*) *platura*), is generally of minor importance to sugarbeet and table beet production, it has been severe on maize, potato, carrots, soybeans, lettuce, spinach, onions, beans and several other crops, particularly in situations where synthetic pesticides are not an option for control. This species is extremely polyphagous and may have up to five generations per season depending on food availability and environmental conditions. In 1993 and 1996 I found low numbers of SCM larvae on sugarbeets near Powell, Wyoming, but it was unclear to what degree the roots were damaged from this insect or others. With the use of organophosphate and carbamate insecticides in much of the area, it is likely the SCM is largely controlled inadvertently as part of the SBRM management program.

While this insect was not the intended focus of the project at the outset, we do feel that the potential for use of *S. tetanopsis* on the organic farm may spur on development and interest in *S. tetanopsis* as a biocontrol agent. As the price premium paid for organic produce is often significant and it represents the fastest growing area of agriculture in the U.S. and many other countries, the economic incentive for a company to invest in this fungus as a potential biopesticide is enhanced greatly. The lack of viable pest control alternatives for the SCM in this restricted-use agricultural system (*e.g.*, no GMOs, no conventional chemical pesticides) increases the need for agents such as *S. tetanopsis*.

As with any pathogenic agent, host specificity of the pathogen is critical. Effective pest control with minimal or no impact on beneficial insects and other invertebrates is examined closely during the registration process. Previous test in the greenhouse demonstrated a lack of plant pathogenicity for this fungus when evaluated on at least two cultivars of the following crops: sugarbeet, sorghum, maize, wheat, barley and sunflower. Inoculations of tobacco hornworms, lady bird beetles, sunflower leaf beetles, gray stem weevils and green lacewings have all indicated a lack of pathogenicity of *S. tetanopsis* for these non-dipteran insects. Experiments also suggest that the pathogenic potential of *S. tetanopsis* toward *Drosophila melanogaster* and *Musca domestica* is minimal to non-existent, at least under the conditions examined. Secondary impacts on insects other than SBRM or SCM can complicate the registration process. It is unclear what factors dictate the host range of this or most other fungal entomopathogens, but it is clear that the range of *S. tetanopsis* is fairly narrow and may be restricted to a subgroup of dipterans.

Current efforts are focused on examination of the host range of this entomopathogen to learn more of the biology of *S. tetanopsis* and to engender interest from commercial concerns who

examine marketability of this biocontrol agent very critically. Further bioassay testing is underway with non-target insects, both of a beneficial and pest nature, to support the specificity inherent in the pathogenicity of this fungus.

Sporulation of *S. tetanopsis* has been demonstrated on maize and barley grain, however the timing and quantity produced under the conditions tested were not satisfactory for biopesticide development. Evaluation of nutritional amendments to whole grain and the oatmeal-based artificial medium currently used for spore production are continuing. Deposition of a granular or grain-based inoculum in-furrow would be preferable for field application as compared to a liquid formulation or wettable powder, hence, work in this area will continue. With the observed *in vitro* saprophytic abilities of this organism it is plausible that an amended inoculum, such as imbibed or fortified grain, may serve well as a delivery medium at planting.

BEET SUGAR
DEVELOPMENT FOUNDATION
BOARD OF DIRECTORS